Report No. DOT/FAA/CT-81/76

LEVEL II

(12)

EFFECTS OF DIFFERENT DISTRIBUTIONS OF TRAINING TIME ON THE ACQUISITION OF CONTACT FLYING SKILLS

AD A104138

Embry-Riddle Aeronautical University
Regional Airport, Daytona Beach, Florida

Seville Research Corporation
Pensacola, Florida

FINAL REPORT

JULY 1981

Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

Prepared for

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER
Atlantic City Airport, N.J. 08405

81 9 14 076

title on cover correct per W. W. [illegible] Seville C P 904-[illegible]

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturer's names appear herein solely because they are considered essential to the object of this report.

(12) 156

(14) SEVILLE-TR-81-07

Technical Report Documentation Page

1. Report No. DOT/FAA/CT-81/76	2. Government Accession No. AD-A104 138	3. Recipient's Catalog No. (11)
4. Title and Subtitle (6) Effects of Different Distributions of Training Time on the Acquisition of [redacted] Flying Skills, Contact		5. Report Date Jul[redacted]981
		6. Performing Organization Code
		8. Performing Organization Report No. TR 81-07
7. Author(s) (10) J. B. Shelnutt, W. D. Spears [redacted] W. W. Prophet		
9. Performing Organization Name and Address Embry-Riddle Aeronautical University Regional Airport Daytona Beach, FL 32014 and Seville Research Corporation 400 Plaza Building Pensacola, FL 32505		10. Work Unit No. (TRAIS) (15)
		11. Contract or Grant No. DOT-FA79NA-6040
12. Sponsoring Agency Name and Address Federal Aviation Administration Technical Center Atlantic City Airport, NJ 08405		13. Type of Report and Period Covered (9) Final Report, Jul[redacted]980 — Jul[redacted]981,
		14. Sponsoring Agency Code
15. Supplementary Notes (18) FAA-CT (19) 81-76		

16. Abstract

As costs rise in general aviation, many private pilots are forced to reduce the rates at which they fly, both during training and after certification, in order to spread out expenses. This report describes the results of the first phase of a two and one-half year study designed to study the impact on pilot performance of reductions in the rates at which student and private pilots fly. The major objective of the first phase of the study was to determine the impact of different rates of flying during private pilot training on the effectiveness and efficiency of instruction. The second phase of the study, which was still in progress when this report was written, will assess the impact of differences in the rates of flying before and after certification on the retention of flight skills after certification.

In general, it was found that different rates of flying during training had no significant influence on overall instructional effectiveness. The different rates did have a significant, practical impact on instructional efficiency. Students whose flying was spread out more (i.e., distributed) tended to fly fewer flight hours, particularly dual hours with their instructors, than students whose training was more concentrated. In response to questions on an opinion survey, students in the concentrated flying program indicated that they felt their training was more harried and that it distracted them more from their jobs. They were also less confident and less positive toward their flight training.

17. Key Words Private Pilot Flight Training General Aviation Flight Skills Skill Acquisition Skill Retention	18. Distribution Statement Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	164	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

393148

METRIC CONVERSION FACTORS

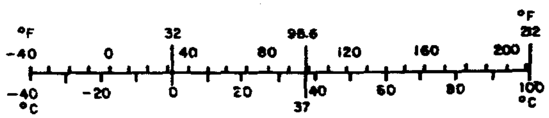
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



EXECUTIVE SUMMARY

BACKGROUND.

As with costs in other sections of the American economy, the expenses associated with owning and operating general aviation aircraft are rising rapidly. One segment of the general aviation pilot community that is hit particularly hard by cost increases are private pilots who fly for recreational purposes and as a preferred method of travel for their own business and personal reasons. As costs rise, many of these pilots are forced to fly less frequently in order to spread their expenses over a longer period. Such reductions in the rate at which they fly may occur both during training for private pilot certificates, especially since instructional costs are added to other expenses, as well as after certification.

The possible impacts of such reductions in flying time on private pilot training and on the proficiency of private pilots in the years following certification are unknown. Limited information currently exists concerning the influence of different distributions of training time on the effectiveness and efficiency of private pilot instruction. Similarly, little information exists concerning how different rates of flying affect the retention of critical flying skills required of private pilots to exercise the privileges of their certificates. Such information could aid in the development of efficient and effective pilot training/retraining programs and of procedures for their associated reviews of pilot proficiency.

OBJECTIVES.

In recognition of the need for this information, the Federal Aviation Administration (FAA) Technical Center has initiated a two and one-half year study to investigate the impact of different rates of flying on pilot training and the proficiency of certificated pilots. This report describes the results of the first phase, approximately the first nine months, of this project. The second phase, which was in progress at the time this report was written, will be reported later.

This initial phase of the study had two major objectives. The first was to determine if different distributions of training time, i.e., the rates at which pilots fly and attend ground school, have an impact on (1) the final level of proficiency attained by student pilots at the end of their training; and (2) the efficiency of instruction. The second major objective was to develop a data base describing the level of flying skill attained by individual pilots at the end of their training. This data base will be used in the second phase of the study as a standard of comparison--i.e., a baseline--for analyzing the retention of flying skills by these pilots in the two-year period following their certification. In addition to these major objectives, the first phase also had a secondary objective, i.e., to determine the ability of pilots to assess the adequacy of their own flying skills. This objective was included to lay the foundation for subsequent analyses in the second phase which will be devoted to gaining a better understanding of the ability of private pilots to determine their own training needs, i.e., to determine when

they need to practice a given flight task in order to retain or regain their proficiency on that task.

METHOD.

The study is being carried out at the FAA Technical Center in Atlantic City, New Jersey. During the first study phase reported here, two groups of student pilots were trained using programs that differed only in the frequency with which flight lessons and ground school sessions were scheduled. These frequencies were selected so as to result in one program that lasted approximately three months (Program A) and another that lasted approximately six months (Program B). A total of 58 student pilots, all without previous flight experience, served as subjects in the study. Of these, 42 completed training (24 in Program A and 18 in Program B).

Four flight tests were administered during the training program, one at the end of each main phase of flight training (i.e., Presolo; Basic Pilot Operations; Cross-Country Flight Operations; and Preparation for the Private Pilot Flight Test). These flight tests were scored using the Pilot Performance Description Record (PPDR), an objective performance measurement instrument that enables an accurate, detailed description of pilot performance to be recorded. The PPDR was divided into three task subsets--I, II, and III. Subset I contained tasks concerned with basic flight operations, e.g., normal takeoffs and landings, while Subset II contained tasks concerned with advanced flight maneuvers, e.g., accelerated stalls, maximum performance takeoffs. Subset III contained tasks involved in cross-country flights. The first flight test was scored using only Task Subset I. The second one was scored using both Subsets I and II. Finally, the third and fourth checkrides were scored using all three subsets--I, II, and III.

In addition to the PPDR, five other measures were developed specifically for use in the present study.

(1) A series of six written quizzes developed by E-RAU personnel and administered periodically during the ground school.

(2) A final exam also developed by E-RAU personnel and administered at the end of ground school.

(3) A questionnaire that assessed the ability of students to predict how well they would perform on the fourth checkride.

(4) A questionnaire that assessed the ability of students to evaluate their performance on the fourth checkride after they had completed it.

(5) A Student Opinion Survey designed to assess student reaction to the training program and flying in general.

Further, the following data were also collected.

(1) Scores on the FAA private pilot-airplane written test.

(2) Scores on the FAA private pilot-airplane flight test.

(3) Number of flight hours and other instructor-contact hours accumulated by the students during flight training.

The data described above were used in the first phase of the study to analyze the impact of different distributions of training time on the efficiency and effectiveness of instruction. During the second phase of the study, similar data will be obtained at eight-month intervals over a two-year period. The second phase results, together with those of the first phase, will be used to assess the impact of different rates of flying, both before and after certification, on the retention of flying skills.

RESULTS.

The results of the experiment can be discussed under four major categories of findings: (1) training effectiveness; (2) training efficiency; (3) assessment of own performance; and (4) perception of training. Table 12 in Section IV summarizes the findings with respect to each of the measures employed in the study.

TRAINING EFFECTIVENESS. In general, with respect to the overall performance of the students at the end of ground and flight training, there were no significant differences between Programs A and B. When performance was considered with respect to the separate PPDR Task Subsets (I, II, and III) on the fourth checkride, however, certain patterns of differences did appear. Students in Program B made fewer errors on tasks in Subsets I and II, while students in Program A tended to make fewer errors on tasks in Subset III.

TRAINING EFFICIENCY. Training efficiency was assessed in three ways: (1) the number of flight hours; (2) the patterns of student progress through flight training as measured on the four checkrides; and (3) the patterns of progress of the students through ground school as measured on the six written quizzes.

Students in Program B received fewer total flight hours during their training than did students in Program A. This difference in total time was entirely due to a substantial difference in dual flight time; there was no such difference in solo flight time. Other significant differences in flight time, when they occurred, also favored Program B--i.e., students in Program B flew fewer hours prior to Checkrides 3 and 4.

The pattern of Program B tending to be more efficient is also apparent in measures of the progress of the students through the flight training programs, i.e., in the patterns of the PPDR scores obtained on the four checkrides. When significant differences were observed, they were almost always in favor of Program B. Performance of tasks in Subset II, for example, was better for Program B on all three checkrides (2, 3, and 4) on which this subset was measured. This superiority is illustrated in Figure 6 in Section III. Thus, students in Program B tended to fly less, at least with their instructors, and tended to perform better at various flight checkpoints during the program.

The relative efficiency advantage of Program B over A held true only for flight training, however. When the pattern of academic performance on the six written quizzes during ground school was examined, it revealed that students in Program A scored higher than those in Program B on all quizzes, especially

the last three. Nevertheless, the Program B students did catch up by the end of the ground school with the result that there was no difference between groups on the two end-of-course written tests.

ASSESSMENT OF PERFORMANCE. Using the preflight questionnaires employed in this study, the students, taken as a group, were not able to predict the number of errors they would make on the fourth checkride; nor were they able to evaluate their own performance accurately after they had completed the fourth checkride. Some students, however, were better than others at predicting and evaluating their performance. Unfortunately, there was no way to identify beforehand which students would be better able to predict and evaluate their own performance.

PERCEPTION OF TRAINING. Based on their general response to the Student Opinion Survey, the students in both programs felt very positive toward their flight training, with those in Program B being slightly more positive than those in Program A. With respect to specific survey questions, only a few differences occurred between the responses of students in the two programs. Students in Program A felt that their flight training was more harried and that it distracted them more from their job. They also reported more difficulty in remembering what was learned. Students in Program B would have preferred more frequent flight lessons. Finally, using measures on the Student Opinion Survey and the pre- and post-flight questionnaires, it was observed that students in Program B were more confident in their flight training than those in Program A.

CONCLUSIONS.

In general, these data suggest that the lengthening of private pilot training to spread out training expenses as these costs rise will not have a serious impact on the effectiveness of instruction, at least with respect to performance at the end of instruction. Insofar as the Phase I results are concerned, there were no practical, comprehensive differences in instructional effectiveness between the two programs.

Whether training is distributed or concentrated does appear to have an impact on instructional efficiency. Students in the longer program flew fewer flight hours, particularly dual flight hours, than did those in the shorter program. Given the costs (and fuel consumption) associated with flight hours, especially dual hours, this finding is of substantial practical importance.

The increased efficiency of the longer program is also reflected in the patterns of student progress through flight training. When differences existed, students in the longer program tended to perform better on the four checkrides administered periodically during training. A different trend appeared, however, when patterns of student progress through ground school training were assessed. In this case, students in the shorter program did better on the periodic written quizzes given during ground training. Thus, it would be beneficial to schedule ground and flight training segments at different rates to take advantage of positive aspects of concentrated and distributed training.

In agreement with observed differences on training efficiency, certain patterns appeared in the way students perceived their training. Students in the longer program felt slightly more positive toward their flight training, although they preferred to have flown more frequently. Students in the shorter program felt their flight training was more harried and that it distracted them more from their job. Additionally, students in the shorter program appeared to be less confident in their training than those in the longer program.

PREFACE

This report describes the results of the first phase of a study of the impact on pilot performance of the rates at which student and private pilots fly, i.e., in the manner in which their flying is distributed over calendar time. Reductions in rates of flying are projected due to increased aircraft operating costs, possible fuel shortages, and other factors making it expensive and difficult for these pilots to fly. The overall study investigating such effects will require two and one-half years to complete. The first phase of the effort reported here required approximately nine months to complete. The major goal of the first phase of the study was to determine the effects of different distributions of flight time <u>during</u> private pilot training--i.e., differences in the rates at which flight lessons are scheduled--on the efficiency and effectiveness of the instruction. The second phase of the study, still in progress at the time this report was written, will investigate the effects of different distributions of flight time, both <u>before</u> and <u>after</u> certification, on the retention of private pilot flying skills.

Both phases of this effort, along with several other projects, are part of an ongoing task order research program sponsored by the Federal Aviation Administration (FAA) Technical Center (Contract Number DOT-FA79NA-6040). This research program is devoted to the identification and solution of human factors problems in general aviation. Work on this program is being performed jointly by the Embry-Riddle Aeronautical University (E-RAU) Research Center, as prime contractor, and the Seville Research Corporation, under subcontract to E-RAU. With respect to the research reported here, Seville was responsible for design of the study, analysis of the data, and preparation of this report. E-RAU was responsible for development of the flight program, training of students, collection of the data, and provision of training equipment, instructors, and support personnel.

Dr. Jerome I. Berlin, Director of the E-RAU Research Center, is Program Manager for the prime contract. Dr. Wallace W. Prophet served as Seville's Program Manager for this effort, and Dr. Jack B. Shelnutt as Project Director. Dr. William D. Spears of Seville was responsible for much of the data analysis. Dr. Jerry M. Childs and Mr. Edward Miller of Seville aided in the development of the pilot performance measurement instruments. Mr. E. Peter Denlea, Associate Director of the E-RAU Research Center, coordinated all research activities and provided overall management of training and data collection. Supervision of flight training and data quality control assistance were provided by Mr. Douglas Berchem of the E-RAU Research Center. Data were collected by Mr. Ray Rutt, Mr. Tony Frock, Mr. Michael Sperry, and Mr. Tad McGee of E-RAU. The Contracting Officer's Technical Representative for the FAA Technical Center was Mr. Douglas Harvey.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

LIST OF ILLUSTRATIONS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

I. INTRODUCTION

BACKGROUND.

As with costs in other sections of the American economy, the expenses associated with owning and operating general aviation aircraft are rising rapidly. This cost escalation in general aviation is attributable to several sources--increases in fuel costs; higher purchase prices for aircraft and avionics; increasing interest rates for financing purchases; rising maintenance costs; increases in various aviation-related taxes and fees; and the rise, due to general inflation, of a host of other expenses faced by general aviation aircraft owners and pilots. For general aviation to continue to grow in importance to American society, it must meet the substantial challenges posed by these rising costs.

One segment of the general aviation pilot community that is hit particularly hard by such costs are private pilots who fly for recreational purposes and as a preferred method of travel for their own business and personal reasons. They are not full-time, professional pilots, but rather earn their income in other ways and, by regulation, cannot charge for their services as pilots. Thus, they must pay flight expenses themselves, although some of these costs may be tax deductible as business expenses. As costs rise, many of these pilots are forced to fly less frequently in order to spread their expenses over a longer period. Such reductions in the rate at which they fly may occur both during training for private pilot certificates, especially since instructional costs are added to other expenses, as well as after certification.

Consideration of the possible consequences of reductions in the rates at which student and private pilots fly raises a number of critical questions for which there are currently no firm answers. Many of these questions concern the effect of such reductions on flight training. If training is spread out over longer periods, for example, is the efficiency of instruction affected? That is, will student pilots actually need to accumulate a greater number of flight hours before they are certificated as a result of reduced instructional efficiency or, conversely, is the lengthened instruction perhaps more or equivalently efficient when compared with training completed in shorter calendar time periods? Determination of the influences of different distributions of training time on instructional efficiency could aid students and their instructors in dealing with the economic consequences of different rates of scheduling flight lessons. They thus could make more informed decisions concerning costs and the allocation of training resources.

Of additional concern is the impact of reductions in the rate at which student pilots fly <u>during</u> training on their performance <u>after</u> they are certificated. The gravity of this issue is apparent in the fact that certificated pilots flying for pleasure have higher accident rates than pilots in any other sector of general aviation (see Figure 1). Factors affecting training effectiveness are of crucial concern in that they directly influence how well student pilots are prepared at the end of their training to exercise the privileges of their private pilot certificate. Moreover, the degree of mastery attained by pilots during training is the most significant factor influencing the retention of flying skills after certification (Prophet, 1976).

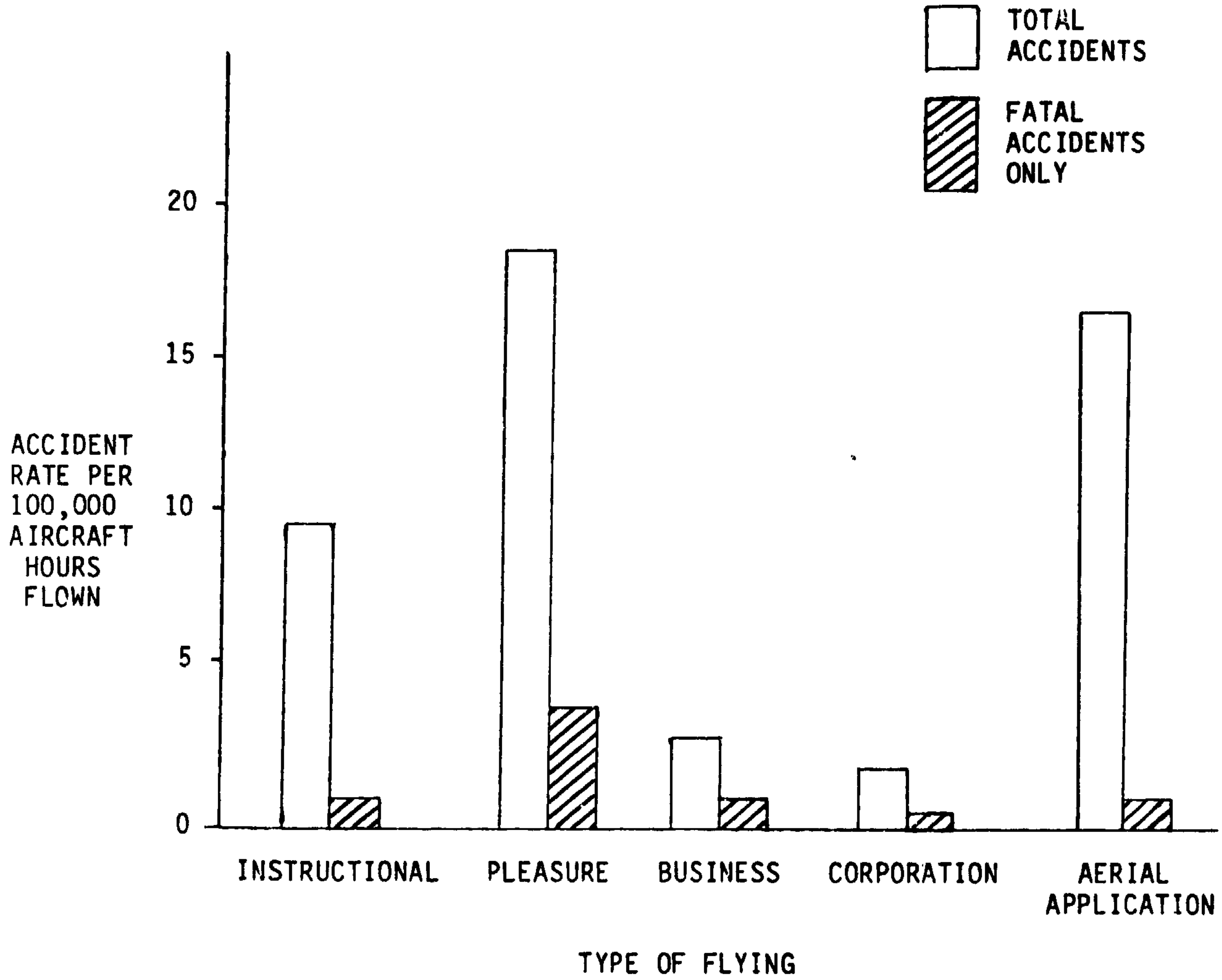


FIGURE 1.--COMPARISON OF 1978 ACCIDENT RATES PER 100,000 AIRCRAFT HOURS FLOWN ACROSS DIFFERENT SEGMENTS OF GENERAL AVIATION (SOURCE: NATIONAL TRANSPORTATION SAFETY BOARD).

Training effectiveness, especially as it relates to degree of mastery and its influence on retention, is a complex issue. All private pilots must meet certain minimum performance standards set by the Federal Aviation Administration (FAA) in order to be certificated (FAA, 1975). However, it is possible that one can meet minimum performance requirements at the end of training, yet lack the thorough mastery of flight skills that promotes retention of those skills and subsequent flight safety. Several factors involved in original training affect degree of mastery. One such factor is the relative concentration of training over calendar time. It is possible, for example, that spreading training over a moderately long time period can sometimes result in greater mastery, as shown by retention, than concentrating the same amount of practice in a short period. Similarly, spreading practice over extremely long time periods may result in unacceptable rates of forgetting. Thus, just as reduced rates of flying during training might affect instructional efficiency for better <u>or</u> for worse, so may reduced rates improve or degrade instructional effectiveness, as manifested at the end of training and also in the years following certification.

Finally, one other concern, highly related to the one just described, is the impact of different rates at which private pilots fly <u>after</u> their certification on the retention of their flying skills. Even the skills of the most proficient pilot will degrade over time if not practiced regularly. Evidence of such degradation is apparent in the common experience of pilots who attempt to fly after extended periods of nonflying, or who attempt to perform flight tasks that they have practiced rarely since initial training--even if they fly regularly. Such attempts may result in serious errors in the execution of procedures, control of the aircraft, or even in making decisions crucial to the safety of flight. These errors, in turn, may result in accidents, accidents that could have been prevented if skill loss had been forestalled or at least remedied through effective recurrent training. Thus, in addition to the need for better understanding of the impact of different rates of flying on the efficiency and effectiveness of student pilot instruction, information is also needed concerning the impact of different rates of flying <u>after</u> training on the retention of once proficient flying skills. Such information would aid in the development of recurrent training that would maximize skill retention, yet efficiently utilize expensive training resources.

<u>OBJECTIVES</u>.

In recognition of the need for this information, the FAA Technical Center has initiated a two-phase, two and one-half year study to investigate the impact of different rates of flying on (1) the effectiveness and efficiency of student pilot training; and (2) the retention of private pilot flying skills following certification. This report describes the results of the <u>first</u> phase, approximately the first nine months, of the project.

This phase of the study had two major objectives. The first was to determine if different distributions of training time, i.e., the rates at which student pilots fly and attend ground school, have any impact on (1) the final level of proficiency attained by student pilots at the end of their training; and (2) the efficiency of instruction. More specifically, the study was designed to

determine the relative instructional effectiveness and efficiency of two private pilot training programs that differed only with respect to the frequency or rate at which instruction was scheduled. Students in one program flew at one-half the rate of students in the other program. Thus, the amount of calendar time taken for completion of training in this program was, by design, about double that of the other program.

The second major objective of the first phase was to develop a data base describing the level of flying skill attained by individual pilots at the end of their training. This data base will be used as a standard of comparison--i.e., a baseline--for analyzing the retention of flying skill by these same pilots in the two-year period following their certification. The analysis of retention of flying skills over extended periods of time, thus, will be performed in the second phase of the study. This second phase was initiated at the end of the first phase and is still in process at the time of this report. Second phase results will be reported at a later date.

Since the later analyses of retention will require an efficiently organized performance data base, the measurements taken during the first phase had to be designed so that they could be used for assessing both the acquisition of flying skills and the retention of these skills. Therefore, the data obtained during the first phase needed to be examined to determine their usefulness for the purposes of the second phase.

In addition to these major objectives, the first phase also had a secondary objective: i.e., to determine the ability of pilots to assess the adequacy of their own flying skills. This objective was included to lay the foundation for subsequent analyses in the second phase which will be devoted to gaining a better understanding of the ability of private pilots to determine their own recurrent training needs, i.e., to determine when they need to practice a given flight task in order to retain or regain their proficiency on that task. The ability to make valid self-assessments is needed by private pilots because of the lack of structured guidance or formal schedules of recurrent training for most of them. If some pilots are limited in their ability to assess their recurrent training needs, information concerning the scheduling of this training, such as will be produced in the second phase in this effort, will be of vital assistance to these pilots. Moreover, knowledge of the extent to which pilots have such abilities will aid flight instructors and pilots in determining how much to depend on a pilot's own judgment in determining individualized training needs and recurrent training requirements.

Assessments of the ability of pilots to determine their recurrent training needs will, thus, be part of the second phase of this research. It was necessary in the first phase, however, to develop and evaluate the utility of a methodology that could be employed in such assessments. Moreover, measures of the ability of pilots to assess their own performance at the end of training taken during the first phase can be compared with measures of this ability taken during the second phase to determine if such ability changes over time.

In summary, the major objectives of the <u>first</u> phase of the study were (1) to determine if different distributions of training time during private pilot

instruction affected the efficiency and effectiveness of training; and (2) to develop and assess the adequacy of a performance data base for subsequent use in the analysis of the retention of flying skills during the second phase. A secondary objective was to develop and evaluate the use of a methodology for measuring the ability of pilots to assess the adequacy of their own flying skills.

While the results of the first phase are of significant interest in themselves, they also provide the basis for the second phase of the study. The objectives of the second phase of the study are (1) to determine the effects of different distributions of training time during private pilot instruction on the retention of flying skills after certification; and (2) to determine how differences in the rates at which private pilots fly after certification affect their retention of different flying skills.

Given that the research objectives of the total study concern both the acquisition and retention of flying skills, a number of different considerations governed the development of an approach for the accomplishment of these objectives. To aid in explaining the rationale underlying the approach developed for the study, Appendix A briefly reviews these considerations. The first part of that appendix summarizes relevant aspects of the extensive research literature dealing with the impact of different distributions of practice on the acquisition of complex skills. Review of this literature provided useful guidance concerning both the design of the present study and the interpretation of its results. Similarly, review of the research literature on retention of complex skills, summarized in the second part of Appendix A, also provided guidance for identifying high priority research issues related to flying skill retention and determining how such issues should be addressed.

II. METHOD

EXPERIMENTAL DESIGN.

The present report describes the results of only the first phase of the study. The design of the total study is presented below, however, to aid the reader in understanding the context for the approach employed in the first phase. One objective of the overall study was to determine the effects of different distributions of training time on the effectiveness and efficiency of instruction. To accomplish this objective, two groups of subjects were trained using private pilot training programs which differed only in the frequency or rate with which flight lessons and ground school sessions were scheduled. These frequencies were selected such that one program (Program A) lasted around three months, and the other (Program B), approximately six months. Figure 2 illustrates the overall lengths of Programs A and B. Full descriptions of these programs are given in Appendix B. Ground school sessions for students in Program A were scheduled at twice the relative frequency of Program B and, as a result, took half as long (8 weeks versus 16 weeks) to complete. Similarly, students in Program A were scheduled to fly an average of 5.4 hours per week, while those in Program B where scheduled to fly approximately 2.7 hours per week.

Four flight tests (Numbers 1-4 in Figure 2) were administered during each training program. Since these tests corresponded to the ends of the four major segments of each flight training program (see Appendix B), the schedule for their administration was relatively more dispensed over time in Program B than was the case in Program A. Similarly, written tests administered during and at the end of the ground school portion of each program were scheduled to match the different paces of students in the two tracks. The specific nature of the measures taken during the first phase to assess training effectiveness and efficiency will be described later. Comparisons of these measures across programs were intended to reveal the effects of the different distributions of training time on the acquisition of flight skills. These comparisons are presented in the Results section of this report.

Another major objective of the overall study was to determine the impact of different distributions of flight time, both before and after certification, on the retention of flight skills over extended time periods. To accomplish this objective, performance of the private pilots trained during the first phase will continue to be monitored for a two-year period following their certification, as shown in Figure 2. The last measurement point at the end of training in the first phase (No. 4) will provide the first, or baseline, set of data for use in calculation of the retention scores. The performance of pilots will then be measured three more times (Numbers 5-7), at eight month intervals, to obtain additional data sets. Retention results will be presented in a later report.

EXPERIMENTAL SETTING.

The first phase of the study was carried out at the FAA Technical Center in Atlantic City, New Jersey. All of the experimental training programs, both

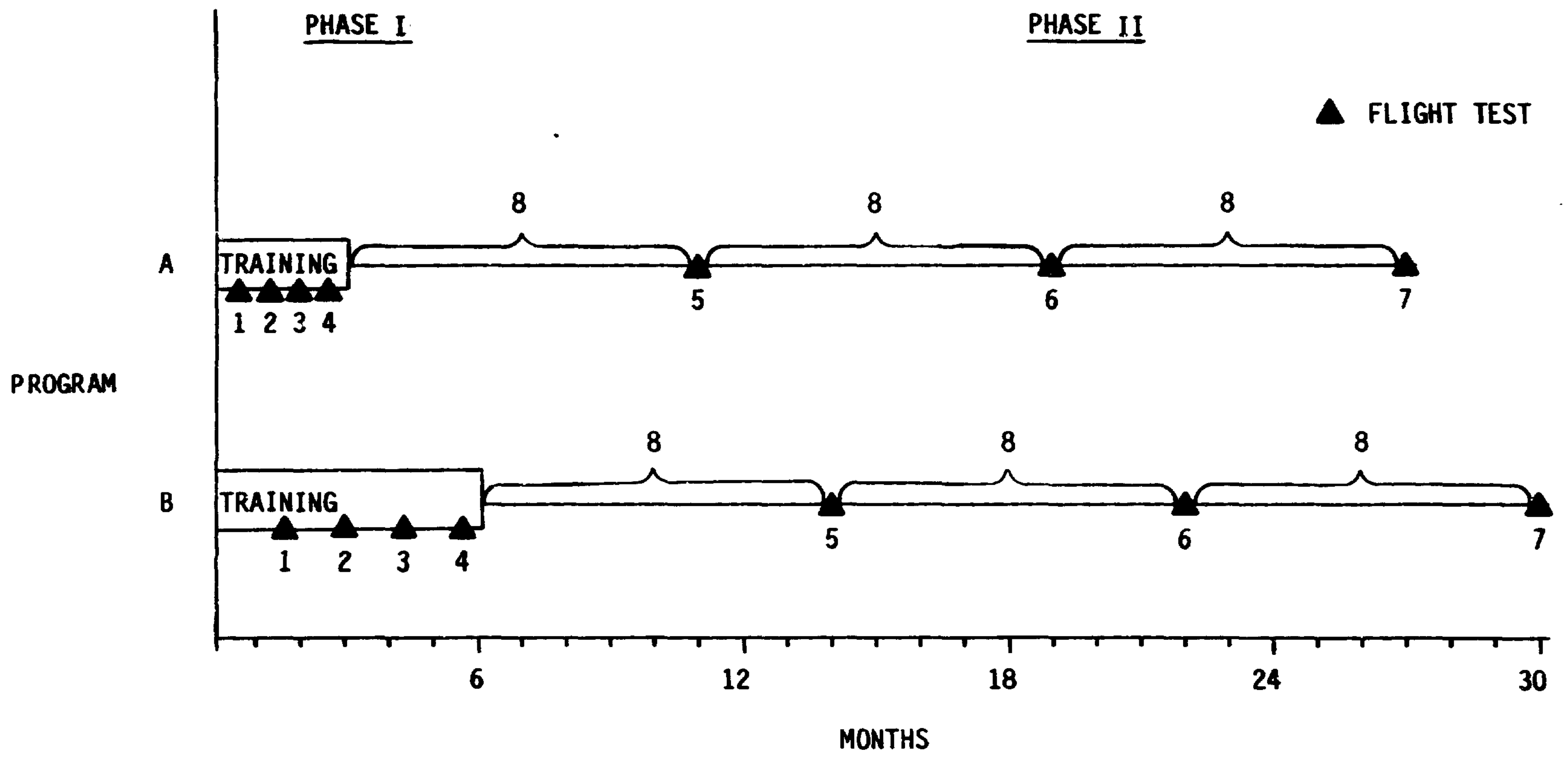


FIGURE 2.--A COMPARISON OF TRAINING AND TEST SCHEDULES FOR PROGRAMS A AND B (PHASES ONE AND TWO).

ground and flight, were developed by Certificated Flight Instructors (CFIs) and their supervisors at the Embry-Riddle Aeronautical University (E-RAU) in Daytona Beach, Florida. These programs were based on the existing FAA-approved, E-RAU private pilot training syllabus employed in the pilot training programs taught at the Daytona Beach campus. The E-RAU syllabus was modified to a limited extent to change the frequencies with which flight and ground school lessons were scheduled, and to accommodate certain operational constraints imposed on use of the programs at the FAA Technical Center. Summaries of the ground and flight training syllabi are presented in Appendix B and discussed under Procedure.

The programs were implemented at the FAA Technical Center through the use of a cadre of experienced E-RAU CFIs who were brought from Daytona Beach and billeted in Atlantic City during the first phase of the study. Additionally, most of the training aircraft (Cessna 172s) and other training materials were also supplied by E-RAU's Daytona Beach campus. Since training during the study was based on a well-established, standardized program, and since it was conducted by experienced personnel familiar with that program, the experimental setting provided an adequate level of experimental control over training content and practices, as well as a high level of training quality.

SUBJECTS.

Fifty-two FAA employees were selected initially to serve as subjects in the present study. They were selected from a larger pool of FAA employees who had volunteered to be subjects in a flight study, the exact nature of which was not disclosed initially. Three criteria guided selection of subjects from the pool: (1) they had no previous pilot training or pilot experience either in aircraft or simulators; (2) they did not have a substantial amount of leave or temporary duty at other locations scheduled during the period in which they would be trained; and (3) they did not plan to retire or be transferred during the course of the study. The 52 subjects were randomly selected from the pool of individuals who met these criteria and wished to remain in the project after being told about it. These subjects were then randomly assigned (with an exception to be described later) to the experimental programs--26 in each program. However, ten of the original group later withdrew from training, and six others were dropped by administrative decision, thereby leaving 36 of the original group. Replacement subjects were randomly selected from the original pool (as long as they met the three selection criteria) up until a time when replacement subjects would not have been able to complete training in the time allotted for the training program in which they were placed (i.e., three or six months). A total of six replacement subjects were used, thus resulting in a final total of 42 subjects; 24 in Program A and 18 in Program B. The information presented in the Results section is based on the performance of these 42 subjects.

Forty-six of the original subjects, as well as all six of the replacements, worked at the FAA Technical Center. Six of the original students came from FAA Headquarters in Washington, DC. They were added to Program A due to constraints on scheduling that prevented any of those subjects from entering Program B. To ensure that the inclusion of all the Washington students in

Program A did not render the two programs noncomparable, subjects in the Washington group were compared with the remaining Program A subjects in preliminary analyses. Also, all Program A vs. B comparisons reported in the Results section were performed twice, once for the full 24 Program A subjects and once for Program A without the six Washington subjects. Without exception, the Washington group subjects were comparable to the other Program A subjects, and their inclusion in program comparisons yielded the same results that were obtained without them. Hence, all analyses reported later include the Washington students.

MEASURES USED IN THE STUDY.

The objectives of the first phase of the study required measures that could be used to determine the (1) effectiveness of training, (2) efficiency of training, and (3) students' ability to assess their own flight skills. These measures would also have to be used to assess flying skill retention during the second phase. To aid in the interpretation of results of both the first and second phases, measures were also needed that described students' perceptions of various aspects of their training--i.e., their attitudes toward flying and toward the training they received during the project. A number of measures were used, some of which served more than one of the above purposes. The measures will be described in this section. The Procedure section will describe the order in which these measures were obtained and the relation of the measurement points to the training schedule. The Results section will describe their use in different analyses.

Six measures were developed specifically for use in the present study. These were:

(1) Pilot Performance Description Record (PPDR).

(2) Final exam developed by E-RAU personnel for use at the end of ground school training.

(3) A series of six written quizzes also developed by E-RAU personnel and administered periodically during the ground school.

(4) A Student Opinion Survey designed to assess student reaction to the training program and flying in general.

(5) A questionnaire that assessed the ability of students to predict how well they would perform on the fourth checkride.

(6) A questionnaire that assessed the ability of students to evaluate their performance on the fourth checkride after they had completed it.

Additionally, the following data were also collected:

(1) Scores on the FAA private pilot written test.

(2) Scores on the FAA private pilot flight test.

(3) Number of flight hours and other instructor-contact hours accumulated by the students during flight training.

PPDR. For the purposes of this study, the most important data are those that permit a detailed assessment of student performance in the aircraft. Measures providing these data had to meet four criteria: (1) they had to include a sample of flight tasks that were sufficiently broad in skill requirements to represent all major private pilot skills; (2) measures had to be obtainable in sufficient detail to permit separate assessments of pilot proficiency on each of the flight tasks, including identification of individual performance errors; (3) the measures had to be objective in the sense that (a) they were based on what a pilot did while performing a task, and (b) if two different observers rated the same performance, the resulting data would be essentially the same; and (4) procedures for observing performance and recording data had to be readily adaptable to use by checkpilots during checkrides.

All of these criteria can be met by suitable adaptations of the PPDR. This instrument, developed originally by Smith, Flexman, and Houston (1952), and subsequently modified by Greer, Smith, and Hatfield (1962) and by Prophet and Jolley (1969), focused on satisfying the four criteria above. Wide usage of the PPDR has further demonstrated its value for assessing flight skills, as well as its adaptability to particular research needs and locales.

Because students' repertoires of skills would increase as additional tasks are introduced during training, the number of tasks included in successive checkrides would increase as well. It was desirable, therefore, to divide the PPDR into three subsets of tasks (referred to as I, II, and III) to be assessed. Subset I tasks, those taught first in the program, were comprised of basic flight skills, (e.g., normal landings, climbs). Subset II tasks, which were introduced somewhat later in training, were generally more complex and required a higher level of skill development, (e.g., soft-field takeoffs, accelerated stalls). Subset III tasks were mainly those associated with cross-country operations. These tasks are listed by subset in Table 1.

The three task subsets were employed to construct flight tests for use on the four checkrides given during training. Table 2 identifies which task subsets were used for each checkride. On Checkride 1, performance of the students was measured only on Task Subset I. On Checkride 2, performance was measured on both Task Subsets I and II. On Checkride 3 and 4, performance was measured on all three task subsets. The schedule for teaching the tasks included in each subset and its relation to the schedule for the four checkrides is described under Procedure.

The particular tasks to include in each set were selected to satisfy the first criterion given earlier. That is, they were chosen so as to be representative of all major private pilot skills. Selections were made by personnel who had considerable experience in the development of pilot performance measures. To guide their selection, they consulted the reports dealing with the development of the PPDR (Smith et al., 1952; Greer et al., 1962; Prophet and Jolley, 1969) as well as the following documents:

TABLE 1.--CONTENTS OF EACH OF THE TASK SUBSETS IN THE PPDR

TASK SUBSET I

Preflight inspection procedures	Engine failure during flight
Engine start and pretaxi check	Before landing procedures
Taxiing to takeoff position	Traffic pattern (uncontrolled field)
Ground communications (to takeoff)	Landing (normal; uncontrolled field)
Engine run-up and before takeoff check	Traffic pattern (controlled field)
Takeoff and departure	Landing (controlled field)
Turn to assigned heading	Taxiing to ramp
Straight and level	Ground communications procedures (to ramp)
Minimum controllable airspeed	Securing aircraft procedures
Takeoff and departure stall	All airborne communications
Approach to landing stall	

TASK SUBSET II

Steep turns (720°)	S-turns across a road
Accelerated stall	Turns about a point
Forced landing procedures	Rate climb (hood)*
Go-around procedures	Magnetic compass turn (W-S; 270) (hood)*
Short-field takeoff	Unusual attitude recovery (hood)*
Short-field landing	180° turns (hood)*
Soft-field takeoff	Airspeed change (hood)*
Crosswind landing	VOR tracking (hood)*
Crosswind takeoff	

TASK SUBSET III

Cross-country planning
VOR tracking (cross-country; inbound)
VOR tracking (cross-country; outbound)
First leg (cross-country)
Diversion to alternate field

*These tasks were performed while the student wore a view-limiting device (hood) that restricted his vision to aircraft instruments.

- FAA private pilot flight test guide (FAA, 1975)
- E-RAU private pilot flight training syllabus developed for the present study (see Appendix B)
- Cessna 172 information manual (Cessna, 1979)
- The Student Pilot's Flight Manual (Kershner, 1979)
- Flight Training Handbook (FAA, 1980)

TABLE 2.--IDENTIFICATION OF THE TASK SUBSETS EMPLOYED IN EACH CHECKRIDE

Checkride	Task Subsets I	II	III
1	X		
2	X	X	
3	X	X	X
4	X	X	X

Scoring flight performance on the PPDR involves assessments of how well a pilot performs each of several components of a task. The components vary from one task to another, both in number and in nature. For present purposes, each component was scored as either "satisfactory" or as an "error." If a particular indicator such as airspeed, heading, bank angle, etc., was within tolerance as defined for that component and task, a "satisfactory" performance was recorded. If the indicator was out of tolerance, regardless of direction (too little or too much airspeed, for example), an error was recorded for that component. A facsimile of the PPDR is given in Appendix C.

The PPDR measures were transformed into percentages of error for analyses. That is, the total number of maneuver components that were out of tolerance during a checkride was divided by the number of scored components, and then multiplied by 100. The maximum number of scored components was 170 for Subset I, 358 for Subset II, and 390 for Subset III.

E-RAU FINAL WRITTEN EXAMINATION. The final written exam was developed by the E-RAU ground school instructor. The major goal of the test was to determine if the students were ready to take the FAA Private Pilot Airplane Written Examination. As such, the content and format of the test were very similar to the FAA exam, which is described later. The knowledge areas and format

(multiple choice) that are described for the FAA exam are exactly the same as those for the E-RAU written exam. Administration of the E-RAU final examination is discussed under Procedure. These tests were scored by determining the percentage of answers that were correct.

E-RAU GROUND SCHOOL QUIZZES. A series of six written tests were developed by the ground school instructor and given to the students to monitor their progress during the course of the ground training. These tests, or quizzes, which were mainly composed of multiple choice questions, addressed the following knowledge areas.

Quiz 1. Aerodynamics
Quiz 2. Airport operations; aircraft weight and balance calculations
Quiz 3. Aircraft performance
Quiz 4. Aviation weather
Quiz 5. Federal Aviation Regulations (FARs)
Quiz 6. Radio navigation

Additional detail concerning the composition of these tests can be obtained by reviewing the ground school syllabus presented in Appendix B. The syllabus describes the specific course content that was covered in the lessons before each of the quizzes was given. Administration of these tests is described in the Procedure section. As with the final exam, these tests were scored by determining the percentage of answers that were correct.

STUDENT OPINION SURVEY. The Student Opinion Survey was developed to determine how the students viewed their training, their achievement, and themselves in pilot roles. The first 17 questions sought general reactions to flying and training content, practices, and conditions. The 18th question, with two parts having 11 response items each, addressed more specifically students' evaluations of aircraft training and ground training. The 19th, and last, question asked students to rate the difficulty they experienced in learning each of 29 maneuvers. (These 29 maneuvers were also included in the PPDR.) The complete Student Opinion Survey appears in Appendix D.

SELF-ASSESSMENTS BY STUDENTS. One objective of the study was to determine how well the students could assess their flight skills; specifically, how well could they predict the quality with which they would perform, and how well could they evaluate their performance immediately after completing it? To answer these questions, two questionnaires were developed, one to be completed just before the fourth and final checkride in the program, and one to be completed immediately after that checkride, and before debriefing by the checkpilot.

Both questionnaires appear in Appendix E. They are identical except for the instructions. One asks students to predict how many errors they will make on the checkride (none to many on a seven-point scale), and the other asks them to estimate the number actually made. Answers were to be provided for each of 29 maneuvers (the same 29 maneuvers that appear in Item 19 of the Student Opinion Survey).

FAA PRIVATE PILOT-AIRPLANE WRITTEN EXAMINATION. The FAA Private Pilot-Airplane Written Test is described in detail in Advisory Circular EA-AC 61-32B

(FAA, 1977). The test was developed by FAA and is administered to all student pilots who desire to qualify for their private pilot certificate. During the present effort, this test was administered by independent FAA personnel who had no other role in the study.

The test covers the following knowledge areas:

- FARs (Parts 1, 61, 71, 91)
- National Transportation Safety Board, Procedural Regulation, 49 CFR 830
- FAA Advisory Circulars
- Airman's Information Manual
- Aviation weather
- Airplane operation
- Engine operation
- Navigation
- Aerodynamics and principles of flight
- Flight instruments and systems
- Radio communications

The FAA exam contains 60 selected multiple-choice items, selected from a larger pool of 600 items (presented in EA-AC 61-32B). Format of the multiple choice items and general procedures for administration of the exam are described in Advisory Circular EA-AC 61-32B (FAA, 1977). These tests were scored by determining the percentages of answers that were correct.

FAA PRIVATE PILOT-AIRPLANE FLIGHT TEST. The FAA flight test is described in detail in Advisory Circular AC 61-54A (FAA, 1975). This advisory circular contains guidance developed by the FAA for conduct of the Private Pilot-Airplane Flight Test by FAA Inspectors and designated pilot examiners (i.e., pilots who are not FAA employees, but who are authorized by the FAA to administer flight tests). All student pilots desiring to receive their private pilot certificate must take and pass this test. During the present effort, these flight tests were administered by independent FAA inspectors and designated pilot examiners.

The Private Pilot-Airplane Flight Test may include assessment of any of the following maneuvers and procedures.

- Preflight operations
- Airport and traffic pattern operations

- Flight maneuvering by reference to ground objects
- Flight at critically slow airspeeds
- Takeoffs and landings
- Maneuvering by reference to instruments
- Cross-country flying
- Maximum performance take-offs and landings
- Night flying - night VFR navigation (optional)
- Emergency operations

Format of the Private Pilot-Airplane Flight Test and general procedures for its administration are described in AC 61-54A. For purposes of the present study, these tests were scored on a pass-fail basis.

FLIGHT HOURS AND OTHER INSTRUCTOR-CONTACT HOURS. The number of flight hours students spent in various activities related to training reflect the efficiency of their instruction. While a minimum number of flight hours is required by FAA regulations (i.e., 20 solo and 20 dual hours), differences among students in flight hours reflect, to a certain extent, differences in the amount of effort they (and their instructors) devoted to training. Accordingly, flight hour measures were obtained as follows:

Hours spent in:

- Solo flight
- Dual flight
- Cross-country (dual and solo) flight

Total hours:

- Preceding the first solo flight
- Preceding Checkride 1
- Preceding Checkride 2
- Preceding Checkride 3
- Preceding Checkride 4

In addition to flight hours, the number of hours the student spent with his flight instructor (in addition to regular ground school) was also recorded. Some of these hours, referred to as "oral" hours, were regularly scheduled in the flight training syllabus. Other oral hours were at the request of the

students or their instructors. As such, the total number of oral hours reflects, to a degree, another aspect of the amount of effort put into training by a student.

PROCEDURE.

Appendix B contains the syllabi for the ground and flight training courses. As previously stated under Experimental Design, Programs A and B differed only in that the rate of training in Program B in both ground and flight courses, was approximately one-half that of Program A. Thus, ground training took two months in Program A and 4 months in Program B. Similarly, flight training took three months, in Program A and six months in Program B.

The ground school was composed of 15 lessons, the contents of which are described in Appendix B. Students in Program A met as a class twice weekly (i.e., covered two lessons per week), while those in Program B met as a class only once a week. The same ground school instructor taught students in both programs. As shown in the syllabus in Appendix B, students received their six quizzes (discussed under Measures Used in the Study) during lessons 2, 4, 5, 7, 10, and 14. They received the E-RAU final written examination during the 15th lesson. Following successful completion of the ground school, the students were given the FAA Private Pilot-Airplane Written Test. This examination was administered by FAA personnel not involved in the present study.

Programs A and B were initiated simultaneously. Additionally, flight training was initiated concurrently with ground school training in both programs. Figure 3 illustrates the relation between ground and flight training in Programs A and B. The schedule of flight training activities is described in detail in Appendix B. Briefly, flight training was divided into four major phases. Phase I, referred to as the Presolo Phase, contained 9 lessons designed to prepare the student to solo the aircraft. Phase II, Basic Pilot Operations, contained 5 lessons designed to increase the student's knowledge of basic and advanced flight operations. Phase III, Cross-Country Flight Operations, was devoted to training the student to conduct cross-country flights. It consisted of 5 lessons. Finally, Phase IV, Pilot Operations-Private Pilot, was designed to allow the student to review previously learned skills and prepare for the FAA private pilot flight test. It consisted of 3 lessons. Thus, flight training was composed of 4 major phases and 22 lessons.

Each of the lessons provided guidance concerning the number of flight hours required, dual and solo, as well as oral hours. Students advanced through the lessons, however, on the basis of their individual proficiency as demonstrated to the instructor in flight and in oral reviews. Thus, the number of flight hours spent on any one lesson or in any one phase was determined, to a degree, by the rapidity with which students mastered the objectives of the lesson or phase.

The programs were designed so that students would fly, when possible, with the same instructor during the entire flight training program. Certain operational constraints, however, prevented this goal from being completely attained. As a result, most students had a major instructor with whom they flew a majority of the time and one or two other instructors from whom they received training the remainder of the time.

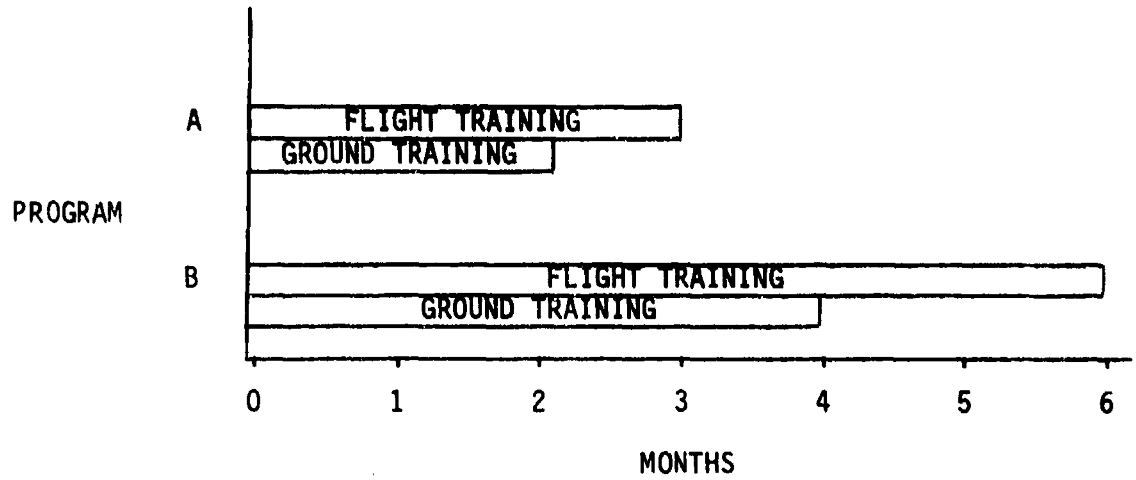


FIGURE 3.--COMPARISON OF FLIGHT AND GROUND TRAINING SCHEDULES IN PROGRAMS A AND B.

The four flight checkrides were given at the end of each of the major phases. Each of the checkrides was structured so that tasks were administered in the same sequence in all checkrides. That is, as Task Subset II was added on checkrides, the order in which tasks in Subset I were assessed remained the same as in Checkride 1. Similarly, when Task Subset III was added, the order in which tasks in Subsets I and II were assessed remained the same.

The checkrides were administered by four checkpilots. Checkrides were scheduled so that the checkpilot for a given student was not directly involved in the training (i.e., was not a major instructor) of the student being assessed. The checkpilots, who aided in development of the PPDR, received extensive ground and flight training concerning the use of the PPDR for checkrides. A handbook for the PPDR, presented in Appendix E, was developed to serve as both an aid during checkpilot training and as an aid for maintaining standardization of the flight tests during data collection.

III. RESULTS AND DISCUSSION

The results of the experiment are discussed under four major headings. First, the effectiveness of training administered in Programs A and B is examined. Second, the efficiency of that training is viewed from the standpoint of amounts of training effort and practice, and of certain training process considerations. Third, the extent to which students were able to predict and evaluate their own performance on the end-of-course checkride is described. Finally, student reactions to training, as measured by the Student Opinion Survey, are analyzed.

1. TRAINING EFFECTIVENESS.

With respect to the first phase of the study, training effectiveness was defined in terms of the performance of the students, both academic and flight, at the end of their training.[1] Training effectiveness in the academic area was defined in terms of two measures of performance: (1) the E-RAU final written exam administered at the end of the ground school; and (2) the FAA Private Pilot-Airplane Written Test. Similarly, flight training effectiveness was based on two measures: (1) the PPDR administered during the fourth and final checkride; and (2) the FAA Private Pilot-Airplane Flight Test.

ACADEMIC PERFORMANCE. Table 3 shows the means (M) and the standard deviations (SD) for students in Programs A and B on the E-RAU final written examination, and the FAA Private Pilot-Airplane Written Test. T-tests were employed to evaluate the differences between the mean scores for Programs A and B. These differences were not statistically significant for either examination, the ts being 0.99 for the E-RAU final examination and 0.47 for the FAA written test.[2] As for the standard deviations, the differences between tracks were also well within the range of chance sampling variation.

FLIGHT PERFORMANCE. As explained in the Method section, PPDR measures were divided into three task subsets--I, II, and III. During the fourth checkride, performance was measured on all three subsets. The analysis that follows addresses (1) differences between the two experimental programs (A and B) in terms of overall performance across all task subsets, (2) differences between

---

[1] As discussed in the Introduction, the effectiveness of flight training can also be viewed in terms of the retention of skills in the years following certification. As such, measures of flight skill retention obtained during Phase II, will also reflect, in part, the effectiveness of the training the pilots received in Phase I.

[2] For readers who are unfamiliar with statistics commonly employed in the behavioral sciences, Appendix G provides a short description of the statistical analyses employed in this report. Deviations from commonly employed analyses are noted in the text, and references are provided for those who wish further information concerning these less common analyses.

programs in terms of performance on each of the separate subsets, and (3) differences among the subsets themselves. The analysis involved an adaptation of the analysis of variance (ANOVA) technique. Using this statistical analysis, it was possible to compare the performance of students in Programs A and B in terms of performance across all subsets as well as to analyze interactions between programs and task subsets, i.e., determine if the relative performance of students in the two programs differed as a function of the separate task subsets. The adaptation of the ANOVA referred to was made necessary by the unequal numbers of students in the two programs. Specifically, the adaptation was the use of an unweighted means solution described by Winer (1971, p. 599f).

TABLE 3.--MEANS (M) AND STANDARD DEVIATIONS (SD) ON THE E-RAU FINAL EXAMINATION AND THE FAA PRIVATE PILOT-AIRPLANE WRITTEN TEST

	E-RAU			FAA		
Program	N	M	SD	N	M	SD
A	24	91.79	7.02	23	92.09	6.77
B	18	89.61	7.15	17	91.06	6.91

A summary of the ANOVA for percent error[1] on the PPDR is shown in Table 4. Overall performance (across all task subsets) of the students in the two programs did not differ significantly. That is, no significant differences between programs were observed when performance was averaged across all task subsets. As can be seen from the F ratios of 20.40 and 4.20 in Table 4, however, significant differences did occur with respect to task subsets and the program by task subset interaction. The pattern of these differences and the interaction is shown in Figure 4.

[1]Analysis of percent error measures in Task Subset II excluded measures obtained for five maneuvers: S turns; turns about a point; rate climb (under the hood); magnetic compass turn (under the hood); and airspeed change (under the hood). These measures were not obtained for 8 of the 18 students in Program B due to operational constraints that prevented their measurement. Similarly, in Task Subset I, the analysis of percent errors excludes "landing at a controlled airport," since completion of all components of this task on the checkride was frequently thwarted due to air traffic considerations for many of the subjects in both programs.

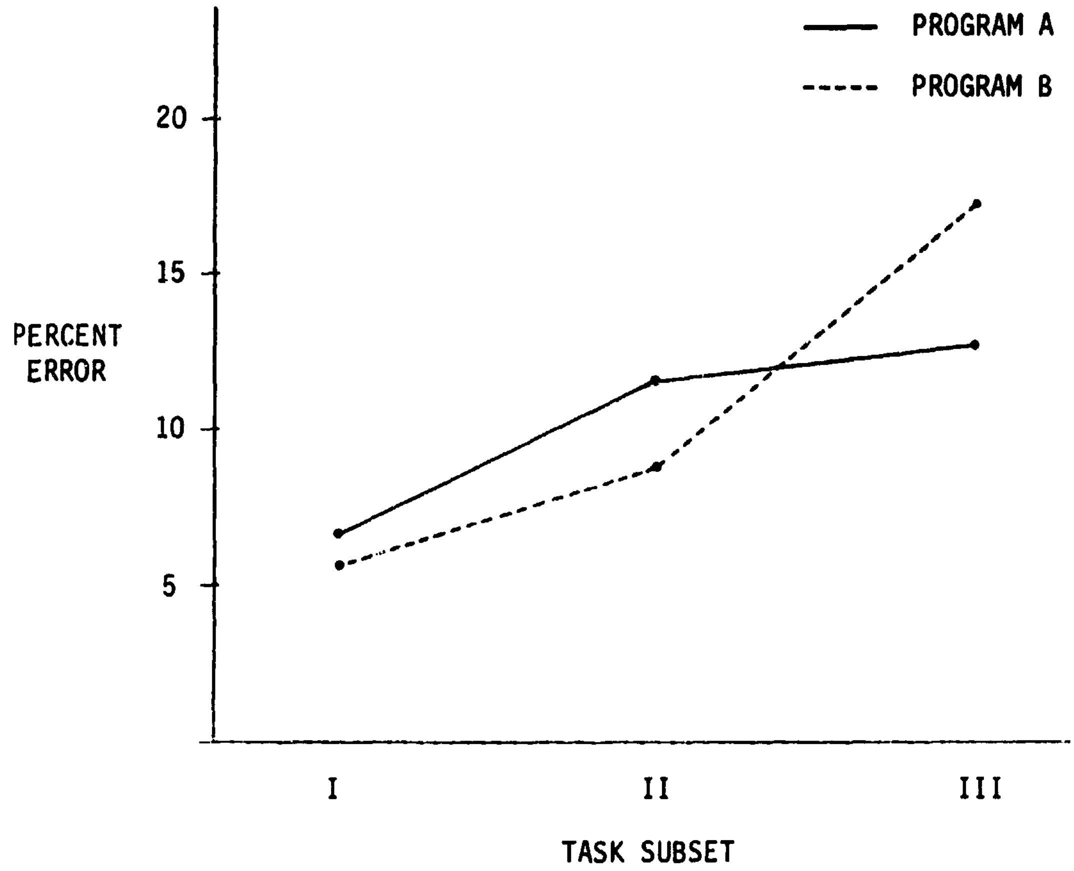


FIGURE 4.--MEAN PERCENT ERROR FOR TASK SUBSETS I, II, AND III PPDR MEASURES ON THE FOURTH CHECKRIDE.

TABLE 4.--SUMMARY OF ANOVA FOR TASK SUBSETS I, II, AND III ON THE FOURTH CHECKRIDE

Source	*df*	Mean square	*F*	*p*
Programs (P)	1	7.61	<1	NS[a]
Between error	40	137.7		
Task subsets (T)	2	747.5	20.40	<.001
P X T	2	154.0	4.20	<.05
Within error	80	36.64		

[a]Not significant.

While students in both programs tended to perform about the same on Subset I, it can be seen in Figure 4 that students in Program B (the six-month program) tended to perform better than those in Program A (the three-month program) on Task Subset II. However, students in Program B performed worse on the average than those in Program A on Subset III. This reversal of pattern on Subsets II and III accounts for the significant interaction effect.

Several plausible hypotheses can be generated to explain the shift in superiority of performance for Program B on Subset II to Program A on Subset III. It may be, for example, that lower rates of training are more conducive to learning the types of tasks, i.e., mainly psychomotor control tasks, represented in Subset II (also Subset I), and less conducive to learning the more cognitive, procedural tasks in Subset III. An alternative, but related, explanation might be that students in Program B learned the Subset III tasks as well as those in Program A, but that they did not retain their skill as well given the greater delay between when the tasks were learned and the last checkride. Past research (discussed in Appendix A) has shown, for example, that cognitive, procedural tasks, such as in Subset III, are less well retained over time than psychomotor tasks, such as in Subsets I and II. It may be, then, that students in Program B were able to retain their skills to perform tasks in Subsets I and II better than they could retain skills to perform tasks in Subset III.

With respect to the differences in performance on task subsets, as reflected by mean percent error, it can be seen that students in both programs tended to make more errors on Task Subset III than on Task Subset II, and that they also tended to make more errors on Task Subset II than on I. These differences between task subset difficulty levels probably reflect differences in the nature of the tasks in each of the subsets and the amount of practice afforded each. As described in the Methods section, tasks in Subset I were relatively simple maneuvers and procedures concerned with routine control of the aircraft. They were learned first and performed routinely throughout training (e.g., normal, as opposed to maximum performance, landings and takeoffs were made on most flights). Tasks in Subset II were usually more difficult and

complex maneuvers requiring more precise control of the aircraft and the timeshared performance of multiple tasks elements. Similarly, tasks in Subset II were learned earlier in the program than those in Subset III. Tasks in Subset III, which came last in the program, were concerned mainly with cross-country flight and were more of a cognitive, and usually more difficult, nature than those in the other subsets. That is, students were required to interpret a wide variety of information, perform various calculations, make decisions, plan, and revise their plans. Thus, the differences in performance on the task subsets probably reflect the order in which the tasks were learned and the amount of practice each received, as well as dissimilarities in the nature of the tasks in each subset.

In summary to this point, it appears that there were no overall differences in the performance of students in Programs A and B on the fourth checkride with respect to the three task subsets. Students in both programs tended to do better on tasks in Subset I than those in Subset II, and better on tasks in Subset II than those in Subset III. Students in Program B tended to do better than those in Program A on Subsets I and II, but worse on tasks in Subset III. However, neither program exhibited a real overall advantage in training effectiveness as reflected in the PPDR end-of-course checkride data.

FAA PRIVATE PILOT-AIRPLANE FLIGHT TEST. Six students in Program A failed the FAA flight test the first time they took it, while only two students in Program B failed it the first time. All of the students who failed except one (in Program A) passed the flight test the next time they took it. The difference between failure rates is well within the range of sampling error, however. The chi squared for the difference, corrected for continuity, was only 0.54, well below the value required for significance at the .05 level. Thus, as with the PPDR data on the fourth checkride, there appears to be no overall training effectiveness difference between programs with reference to performance on the FAA Private Pilot-Airplane Flight Test.

2. TRAINING EFFICIENCY.

The second major aspect of the results is that concerned with the efficiency of the two programs. Training efficiency was assessed with respect to (1) the number of flight and oral hours spent by students in various training activities, (2) the patterns of progress of the students through flight training as measured on the four flight checkrides, and (3) the patterns of progress of the students through ground school as measured on the six written quizzes.

FLIGHT AND ORAL HOURS. The most important questions concerning training efficiency, from the standpoint of practical training procedures, relate to differences in the amount of training effort required for students in each program to reach proficiency in the skills being trained. That is, do students tend to require more or less flight time and a greater or lesser amount of contact with their instructors as a function of how their training is distributed over calendar time periods? Such differences, if they exist, ultimately translate into cost and fuel use differences. The standard training regimens for the two groups in the present study were comparable from the standpoint of quality of formal instruction and the proficiency objectives to be obtained. The only real difference was that Program A received all their

training during a three-month period while Program B's training extended over six months. Thus, differences in amount of effort to reach proficiency would be reflected primarily in the amount of time students spent in preparation for solo and checkrides, i.e., in dual and solo flight hours and in oral hours.

Table 5 shows means (M) and standard deviations (SD) of flight hours and oral instruction hours at various points in the two programs. Also shown are Ms and SDs for various categories of flight hours such as total dual, total solo, cross-country (X-C) solo, etc. As is apparent from the t ratios in the table, students in Program B received significantly fewer hours in the air prior to Checkrides 1 and 3. They also had significantly less dual instruction time and total solo plus dual time (the solo + dual difference shown in the table is due to the difference in dual alone). Two other differences--flight hours preceding the fourth checkride and hours of oral instruction--approached significance, and in both cases students in Program B had fewer mean hours.

TABLE 5.--HOURS IN TRAINING/FLIGHT BY SELECTED CATEGORIES

Category	Program A (N=24) M	Program A (N=24) SD	Program B (N=18) M	Program B (N=18) SD	t
Flight hours preceding:					
Checkride 1	17.35	2.63	15.60	3.10	1.98*
Solo	18.81	2.64	17.73	3.67	1.11
Checkride 2	38.97	3.82	38.69	6.15*	0.18
Checkride 3	51.81	4.34	48.54	6.17	2.02*
Checkride 4	67.55	5.25	63.57	8.70*	1.84
Flight hours spent:					
Solo	26.04	2.71	26.29	5.55**	0.19
Dual	45.93	5.28	39.63	5.64	3.72***
Solo + Dual	71.97	5.70	65.92	8.55	2.75**
X-C Solo	11.20	1.05	12.32	3.04**	1.68
X-C Dual	7.76	2.11	8.03	2.78	0.36
Total X-C	18.96	2.09	20.36	3.82**	1.52
Hours oral instruction	22.45	4.27	20.04	4.53	1.76

*Difference between SDs or Ms significant at or beyond .05 level.
**Difference between SDs or Ms significant at or beyond .01 level.
***Difference between SDs or Ms significant at or beyond .001 level.

The SDs of hour measures shown in Table 5 also had a systematic pattern of differences. They were larger for Program B than for Program A in every instance, and significantly so in five. This result implies an interaction of the training process with characteristics of individual students. That is, the longer training period for Program B resulted in the Program B students

being significantly more variable in their training times than were those in Program A. It should be noted, however, that all instances of Program B's significantly greater variability involved solo flight, and not just direct contact with flight instructors. Variabilities of hours concerned with direct contact with flight instructors were generally comparable for the two programs, as indicated by SDs for Dual and X-C Dual.

The conclusion with reference to training flight time is that the training process was slightly more efficient when the training was spread over six months rather than three. However, one may also examine efficiency in terms of performance as measured during flight training and the manner and rate at which individual skills develop. The next section examines training efficiency in terms of performance over the four flight tests administered during training.

FLIGHT CHECKRIDES. As previously discussed, PPDR measures were divided into three subsets--I, II, and III--corresponding to groups of tasks introduced at successive times during training. As shown in Table 2 in the Methods section, Subset I measures were obtained on each of the four checkrides; Subset II measures were obtained on Checkrides 2, 3, and 4; and Subset III measures were obtained on Checkrides 3 and 4. The following analyses focus on the separate subsets and the students' change in performance over the corresponding checkrides. ANOVAs for repeated observations, adapted as previously described to accommodate unequal numbers of students, were used to analyze differences in the performance of students across checkrides and programs.

Task Subset I. A summary of the ANOVA for percent errors on Subset I of the PPDR measures appears in Table 6. Data for 24 Program A and 18 Program B students are included in the analysis. One maneuver, Traffic Pattern, Controlled, was eliminated from this set because most of the students in the two programs did not have sufficient opportunities to perform it due to operational constraints. The programs did not differ significantly on total errors across all four checkrides. However, the Program-by-Checkride interaction reached borderline significance with a p of approximately .05.

TABLE 6.--SUMMARY OF ANOVA FOR TASK SUBSET I

Source	df	Mean square	F	p
Program (P)	1	68.71	1.00	NS
Between error	40	68.80		
Checkride (C)	3	1409.	34.43	<.001
P x C	3	136.8	3.34	.05
Within error	120	40.92		

Note: Data for Traffic Pattern, Controlled, not included.

The source of the borderline interactive effect is apparent in Figure 5 where means for each program are plotted by checkride. Program B changed from slightly poorer performance than Program A on the first checkride to a somewhat better performance than Program A on the other three. The greatest discrepancy between programs, however, is on the third checkride. Thus, it is the third checkride, given after the cross-country operations phase, that departs most from an otherwise similar pattern of means for the two programs, and hence contributes most to the interaction.

The source of the difference on the third checkride was determined by comparing the two programs maneuver by maneuver. On 7 of the 19 maneuvers in Subset I (Traffic Pattern, Controlled was excluded) no student in either program made an error. On 11 of the remaining 12 maneuvers, however, Program B had a lower mean percent error than did Program A. Furthermore, ts on 4 of the 11 maneuvers reached the .05 level of significance: Traffic Pattern, Uncontrolled; Normal Landing, Uncontrolled; Landing, Controlled; and Taxi to Ramp. The overall superiority of Program B on the third checkride, together with four statistically significant differences, leads to the conclusion that the borderline interaction is a true effect. That is, Program B was actually superior on the third checkride, even though performance differences on the other three checkrides tended to balance the two tracks when all four checkrides are viewed as a whole.

Figure 5 also shows the basis for the highly significant F ($p < .001$) for checkride differences. Percent errors reduced drastically for both tracks from the first to the fourth checkride. Such a finding is, of course, expected, since all subjects should improve in performance, i.e., exhibit significant learning, because of accumulated additional flight experience from one checkride to the next. This finding demonstrates, in part, the validity of the PPDR in that it reveals the ability of the measure to detect different skill levels that would be expected as learning progresses.

Task Subset II. Because data on five tasks were not available for 8 of the 18 students in Program B due to operational constraints that prevented their measurement, two analyses were completed for error measures on Subset II tasks. For the first analysis, which included 24 students in Program A and 18 in Program B, data for the following five tasks were excluded: S turns; turns about a point; rate climb (performed under the hood); magnetic compass turn (performed under the hood); and airspeed change (performed under the hood). In the second analysis, only these five tasks were considered, using the data that were available.

Table 7 presents a summary of the ANOVA for the Subset II error percentages (excluding the five tasks just identified). The programs differed beyond the .01 level of significance, with Program B having the lower overall error. The Program-by-Checkride interaction did not approach significance, however, so the implication is that Program B's superiority was general across all three checkrides. The pattern of differences can be seen in Figure 6 where separate program means are plotted by checkride. Again, differences from the first (Checkride 2) to the last checkride were highly significant ($p < .001$).

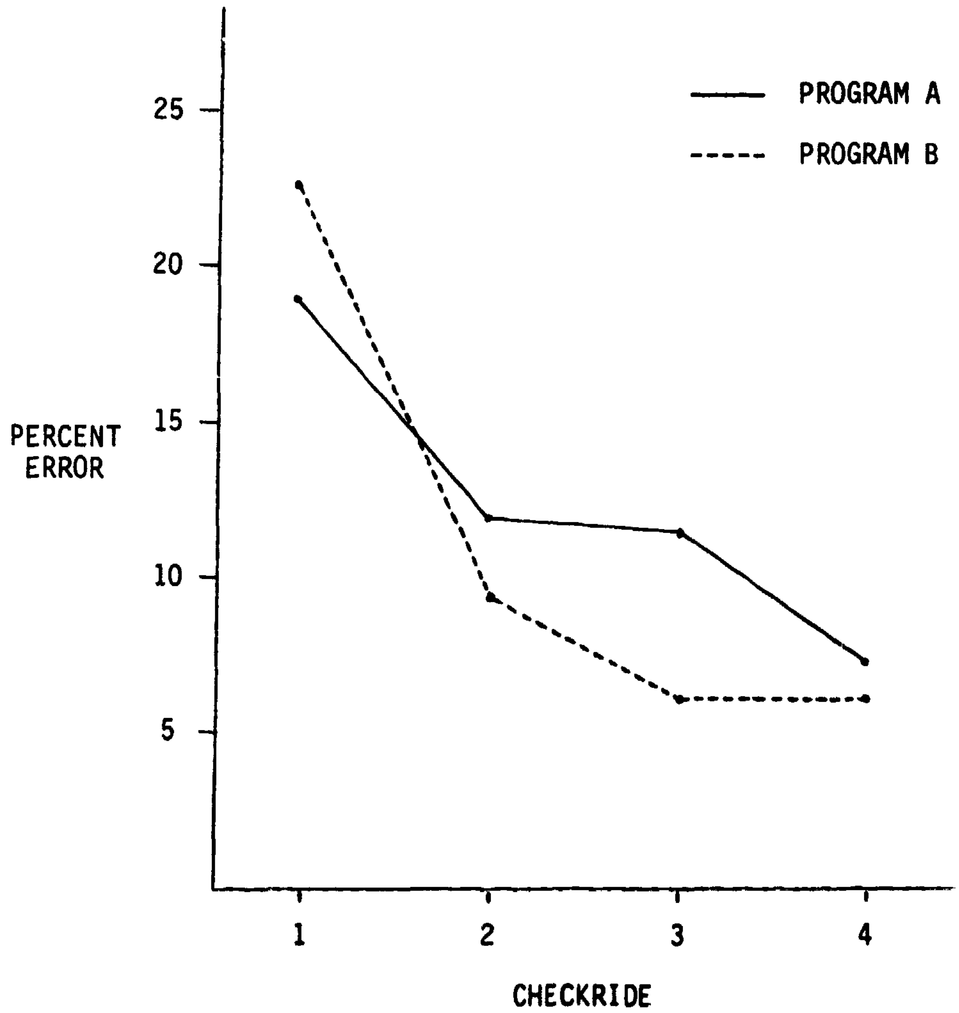


FIGURE 5.--MEAN PERCENT ERROR FOR SUBSET I PPDR MEASURES.

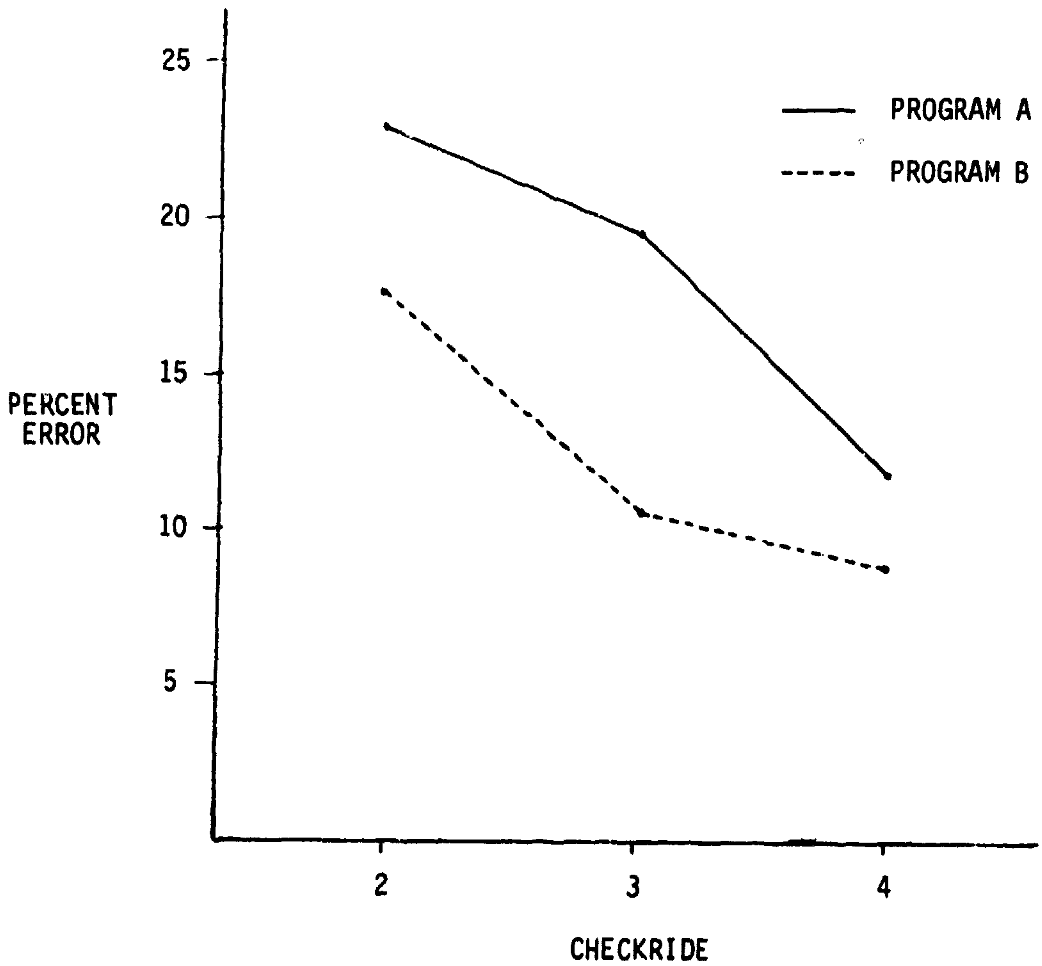


FIGURE 6.--MEAN PERCENT ERROR FOR SUBSET II PPDR MEASURES (EXCLUDING THE FIVE MANEUVERS LISTED IN THE TEXT).

TABLE 7.--SUMMARY OF ANOVA FOR TASK SUBSET II

Source	df	Mean square	F	p
Program (P)	1	825.7	10.57	<.01
Between error	40	78.15		
Checkride (C)	2	977.2	14.40	<.001
P x C	2	80.33	1.18	NS
Within error	80	67.86		

Note: Data for five tasks described in text are not included.

Performance on the five tasks that were excluded in the above analysis was analyzed in a similar ANOVA, using 23 Program A and 10 Program B students for whom data were available. The results are summarized in Table 8. In this case, program differences ($p < .01$), checkride differences ($p < .001$), and the Program-by-Checkride interaction ($p < .001$) were all significant. As can be seen in Figure 7, the Program B students clearly had the lower error rates, with the interaction due to the marked divergence in performance between the two programs on Checkride 3.

TABLE 8.--SUMMARY OF ANOVA FOR THE FIVE MANEUVERS PREVIOUSLY EXCLUDED IN THE ANALYSIS OF SUBSET II

Source	df	Mean square	F	p
Program (P)	1	5148.	11.40	<.01
Between error	31	451.6		
Checkride (C)	2	1789.	13.76	<.001
P x C	2	1081.	8.32	<.001
Within error	62	130.0		

A question naturally arises as to whether the 10 subjects available from Program B were representative of the Program B group as a whole. To answer this question, three additional analyses were completed. In the first, total error percentages by checkride for the 10 Program B students used above were compared with those of the remaining 8 Program B subjects for Subset I tasks, excluding Traffic Pattern, Controlled, as before. In a second analysis, a similar comparison was made of Subset II tasks, excluding the five tasks described previously. In the third, the analysis was repeated using Subset III tasks (only Checkrides 3 and 4 included Subset III maneuvers). The ANOVA

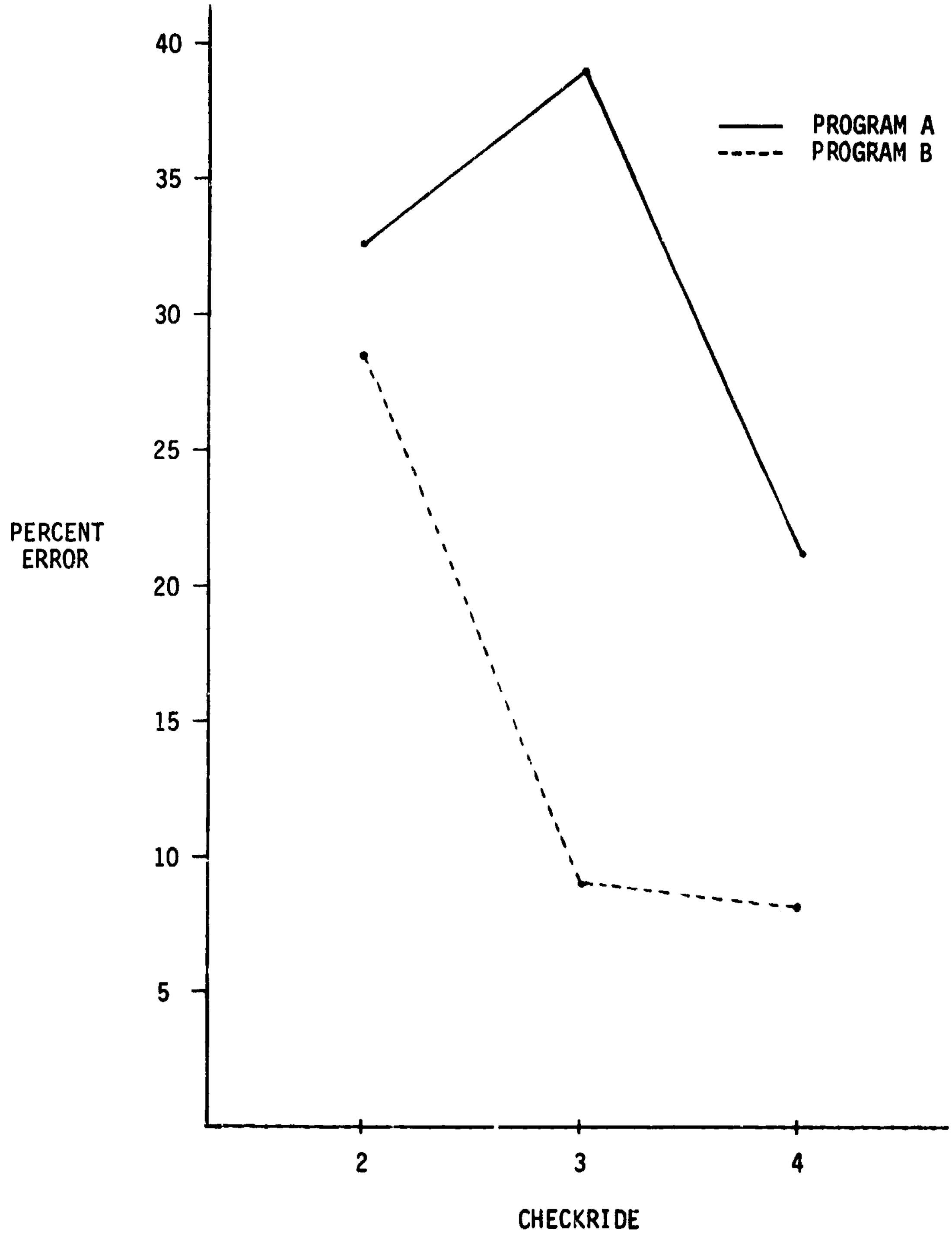


FIGURE 7.--MEAN PERCENT ERROR FOR THE FIVE MANEUVERS EXCLUDED IN THE PREVIOUS ANALYSIS OF SUBSET II.

for repeated observations, adapted for groups of unequal size, was used in each analysis. In no case did the difference between subgroups in Program B, nor the Subgroup-by-Checkride interaction, even approach significance. That is, the 10 subjects used in the comparison with Program A students were comparable on all other PPDR measures to the 8 Program B subjects who were excluded from the comparison with Program A. The conclusion is that the superiority found earlier of the 10 Program B students over the 23 in Program A was due to Program B characteristics as a whole, and not to a bias in the selection of the 10 students in Program B.

Subset III. The basic ANOVA completed for task Subsets I and II was repeated for Subset III, although only Checkrides 3 and 4 could be included since Subset III measures were obtained only on these rides. All 24 students in Program A and all 18 in Program B were included in the analysis. The results are summarized in Table 9. The mean error percentages are depicted in Figure 8. No F was statistically significant, although the Fs of 3.54 and 3.65 for Program and Checkride, respectively, approached the value of 4.08 required for significance at the .05 level. As can be seen in Figure 8, Program A showed some advantage on both checkrides and progress occurred for both programs from the third to the fourth checkride. Nevertheless, the variability within each program was considerable on Subset III tasks, and, as a consequence, the apparent mean differences represented in Figure 8 were not statistically significant.

Overall Flight Performance. To summarize relative training efficiency over all task subsets for the two programs, it would appear that there was no clearcut efficiency advantage for either program. However, progress during training, as reflected by PPDR error rates on the various checkrides, appeared somewhat more rapid for Program B than for Program A, though Program A exhibited a tendency toward better performance than Program B on Subset III tasks. These data favoring Program B would tend to lend support for the efficiency advantage found for Program B with reference to flight hours.

TABLE 9.--SUMMARY OF ANOVA FOR TASK SUBSET III

Source	df	Mean square	F	p
Program (P)	1	522.5	3.54	NS
Between error	40	147.4		
Checkride (C)	1	593.3	3.65	NS
P x C	1	0.62	<1	NS
Within error	40	162.6		

WRITTEN QUIZZES DURING TRAINING. A final aspect of training efficiency is that related to academic performance during training. While of interest, the practical cost connotations of any differences in this area would seem considerably less than those for the flight area just discussed. As was pointed

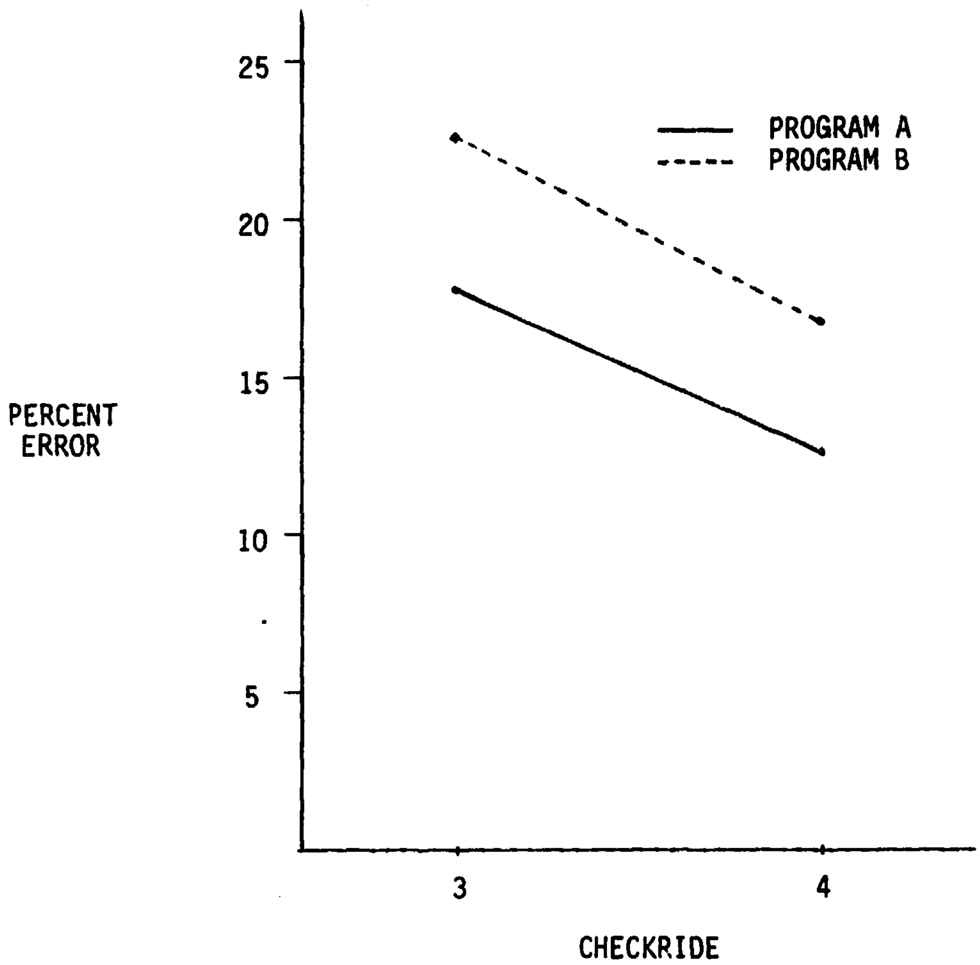


FIGURE 8.--MEAN PERCENT ERROR FOR SET III PPDR MEASURES.

out earlier, students in Programs A and B had generally the same grades on the E-RAU final written examination and on the FAA Private Pilot-Airplane Written Test. It is apparent, however, from results for the six academic quizzes given during training, as shown in Table 10, that test grades during training were different between the two groups. Program B's grades were consistently inferior to Program A's, and Program B was consistently more variable. The means in Table 10 were compared by a repeated measures ANOVA, adapted as before. The results are summarized in Table 11. The overall program differences were highly significant ($p < .001$) and the Program-by-Test interaction ($p < .05$) indicates that the magnitude of differences shown in Table 11 for the last three tests was significantly greater than it was on the first three tests.

TABLE 10.--MEANS (M) AND STANDARD DEVIATIONS (SD) FOR THE SIX PERIODIC WRITTEN TESTS

Test:		1		2		3	
Program	N	M	SD	M	SD	M	SD
A	24	86.2	9.2	74.0	12.5	96.2	9.2
B	18	80.0	15.7	71.7	18.7	92.8	9.9

Test:		4		5		6	
Program	N	M	SD	M	SD	M	SD
A	24	92.1	8.1	89.3	10.4	87.8	11.2
B	18	79.9	13.1	77.1	12.2	71.4	18.1

TABLE 11.--SUMMARY OF ANOVA FOR THE PERIODIC WRITTEN TESTS

Source	df	Mean square	F	p
Program (P)	1	5003.	14.05	<.001
Between error	40	356.1		
Test (Te)	5	2070.	17.97	<.001
P x Te	5	333.1	2.89	<.05
Within error	200	115.2		

From these results, it seems clear that students in Program A consistently performed better than those in Program B during the course of their academic instruction. Thus, Program A can be viewed as relatively more advantageous with reference to in-process academic progress. Yet, as reflected by the end-of-course measures used (E-RAU final examination and FAA Private Pilot-Airplane Written Test), there was no difference between groups at the end of training. Thus, the in-process academic efficiency advantage shown by Program A would seem of no particular practical consequence.

3. SELF-ASSESSMENT OF PERFORMANCE.

The third area of results of concern is that dealing with students' abilities to make accurate assessment of their own performance. Each student's prediction of the number of errors he would make on the fourth checkride, and his evaluation of his performance after that checkride, were ascertained as described in Section II. The primary concern was the degree of accuracy in either case. That is, how accurately can students anticipate the quality of their performance, and how accurately can they evaluate how they actually performed? Answers to these questions are pertinent to any consideration that pilots be permitted to decide for themselves when they need refresher training.

The data were analyzed by correlating predictions and self-evaluations with the actual numbers of errors recorded on the PPDR during the fourth checkride. In computing the correlations, the subjects in the two programs were treated as a single group. Because of missing data, only 37 subjects were available for correlations involving predictions, self-evaluations, and actual errors on 28 maneuvers combined. (One of the original 29 maneuvers, Traffic Pattern, Controlled, was omitted because too few students had an opportunity to perform it.) With reference to the ability of the students to predict how they would perform on the fourth checkride prior to that checkride, there was no correlation between such predictions and subsequent performance (r = 0.00). Neither was there any reliable correlation between their self-evaluation after the checkride and the error made on the checkride (r = +.04). In other words, actual performance was not related either to predictions or to self-evaluations.

Nevertheless, the correlations were repeated separately for each of 26 maneuvers. (Two additional maneuvers, Conducting Engine Run-Up/Before Takeoff Check, and Radio Communication, were omitted because no student made any errors on them.) For pre-checkride predictions, the rs with actual performance ranged from -.24 to +.22, with a mean of zero. For self-evaluations, the range was from -.28 to +.43, with a mean of +.05. The range and mean of rs for predictions and self-evaluations both are within chance expectations for distributions of sample rs when no relationship actually exists.

The data were organized differently for a further analysis of the accuracy of predictions and self-evaluations. Instead of pairing values for individuals and computing rs across individuals as above, group means of predictions and of self-evaluations for each maneuver were correlated with mean actual errors for each maneuver. In this case, only the Traffic Pattern, Controlled maneuver was omitted, thus leaving some 28 maneuvers on which the correlations were based. Moderate correlations were obtained; r = +.42 for mean predictions with mean actual errors, and r = +.48 for mean self-evaluations with mean actual errors. These rs, which are not as subject to sampling errors as those

computed across subjects, indicate that, as a group, the students could discriminate moderately well the extent of relative differences in difficulty they would encounter on various maneuvers, even though they could not predict how they would actually perform as individuals. Hence, a related question was pursued: Do individual students differ in the extent to which they can discriminate relative maneuver difficulties?

To establish the presence of individual differences in ability to assess relative maneuver difficulties, it is necessary only to show that *r*s across maneuvers, computed separately for each student instead of for means of the group as a whole, reliably discriminate among individuals. The data needed for reliability analyses were not available, but an alternate approach established that substantial reliability existed. Specifically, if the two sets of *r* measures in question, those between predictions and actual errors, and those between self-evaluations and actual errors, are themselves correlated, a minimum reliability for each set can be inferred. That is, no correlation between variables can exceed the geometric mean of the reliability coefficients for the measures, so the geometric mean of the reliabilities of the measures involved must be at least as high as their correlation. Of course, the geometric mean will be actually greater than a nonzero correlation of variables to the extent two variables measure independent domains.[1]

Accordingly, the separate subject *r*s, computed across maneuvers for predictions and self-evaluations with actual errors, were transformed to Fisher *z*s and then correlated across subjects. An *r* of .62 was obtained, which is significant beyond the .001 level. Thus, taking .62 as a valid estimate of the correlation between the two sets of *r*s, the geometric mean of the reliabilities of the two sets must be around .60 or higher. Therefore, the individual *r*s across maneuvers reliably discriminate among students, meaning that some students are better able than others to anticipate difficulties they will have with various maneuvers and to evaluate how they actually performed on them.

These data offer little encouragement regarding the use of pilots' predictions or self-evaluations of current performance as bases for recurrent training. Some students were able to make reasonable assessments, but as a group, the students' predictions and self-evaluations were essentially worthless. There is no way at present to identify beforehand which students among the group make reasonable self-assessments. Of course, it must be kept in mind that these students represent relatively low points on the pilot experience continuum. It is possible that as their experience level increases, their insight into their own performance capabilities and recurrent training needs may improve. Further pursuit of this problem should seek to identify characteristics of "good" self-assessors, as well as to determine if the same general patterns of accuracy and inaccuracy hold for more experienced pilots.

4. STUDENTS' PERCEPTIONS OF TRAINING.

The final results of concern are those relating to the students' views of the training they received, its strong and weak points, and the manner in which

[1]Readers not familiar with correlational statistics are referred to McNemar (1969, p. 171*f*) for a detailed discussion of the concepts in this paragraph.

that training affected them. Data regarding students' perceptions of training were collected primarily with the Student Opinion Survey described in Section II. However, two other instruments, the Student Pre-Check Questionnaire and the Student Post-Check Questionnaire, also yielded data related to students' perceptions of training. While the principal purpose of the last two instruments was to evaluate the ability of students to assess their flight skills as discussed in the preceding section, they also revealed something of the students' confidence in themselves and their ability to perform, as explained later.

STUDENT OPINION SURVEY DATA. Items on the Student Opinion Survey covered a variety of content and thus did not allow derivation of a meaningful overall opinion index. Two groups of items formed homogenous sets, however, while the remaining items tapped varied reactions to and satisfaction with training. The homogeneous sets are discussed first.

Item 18 of the Survey had two subsections, one to measure reactions toward training received in the aircraft and the other a comparable measure of reactions toward training received on the ground. Each subsection provided for 11 responses. Adapted reproductions of the scales for the two subsections are shown in Figures 9 and 10. The words at the left and right of each scale represent bipolar extremes of an evaluative dimension, and students were to circle a number from one to six on each scale according to the manner and extent to which that dimension described their training. A mean for each group was obtained for each scale, based on the numbers circled. The means for Programs A and B students are plotted in Figures 9 and 10.

Except for the dimensions Hard-Easy and Harried-Leisurely, positive reactions toward training would be indicated by means toward the left side of each figure. With reference to training in the aircraft (Figure 9), both tracks showed positive reactions, with Program B perhaps being slightly more positive overall. The only statistically significant difference, however, was for Harried-Leisurely, which Program B tended to mark more toward the Leisurely end.

Reactions to ground training (Figure 10) were somewhat less positive overall, but still favorable. There was no general trend of differences between programs, and no difference was statistically significant.

The second set of homogeneous items was the difficulty rating for the 29 maneuvers listed in Item 19 of the Student Opinion Survey. Students were to rate the difficulty they experienced in learning each maneuver, using a scale from 1 (no difficulty) to 6 (extreme difficulty). Using 3.5, the midpoint between 1 and 6, as a dividing point between relative ease and relative difficulty in learning, both Program A and Program B reported only two maneuvers as being relatively difficult: (1) Performing Accelerated Stalls; and (2) Making Crosswind Landings (Uncontrolled Field). When *t*s were computed separately by maneuver, Program B reported significantly less difficulty in learning 3 of the 29 maneuvers: (1) Performing Engine Failure During Flight Procedures ($p < .02$); (2) Performing Forced Landing Procedures ($p < .05$); and (3) Performing a Magnetic Compass Turn under the Hood ($p < .05$). Furthermore, Program B reported lower mean difficulty rating than Program A on 26 of the 29 maneuvers. However, means for ratings of all 29 maneuvers combined ($M = 2.80$ for Program A; and $M = 2.52$ for Program B) were not significantly different.

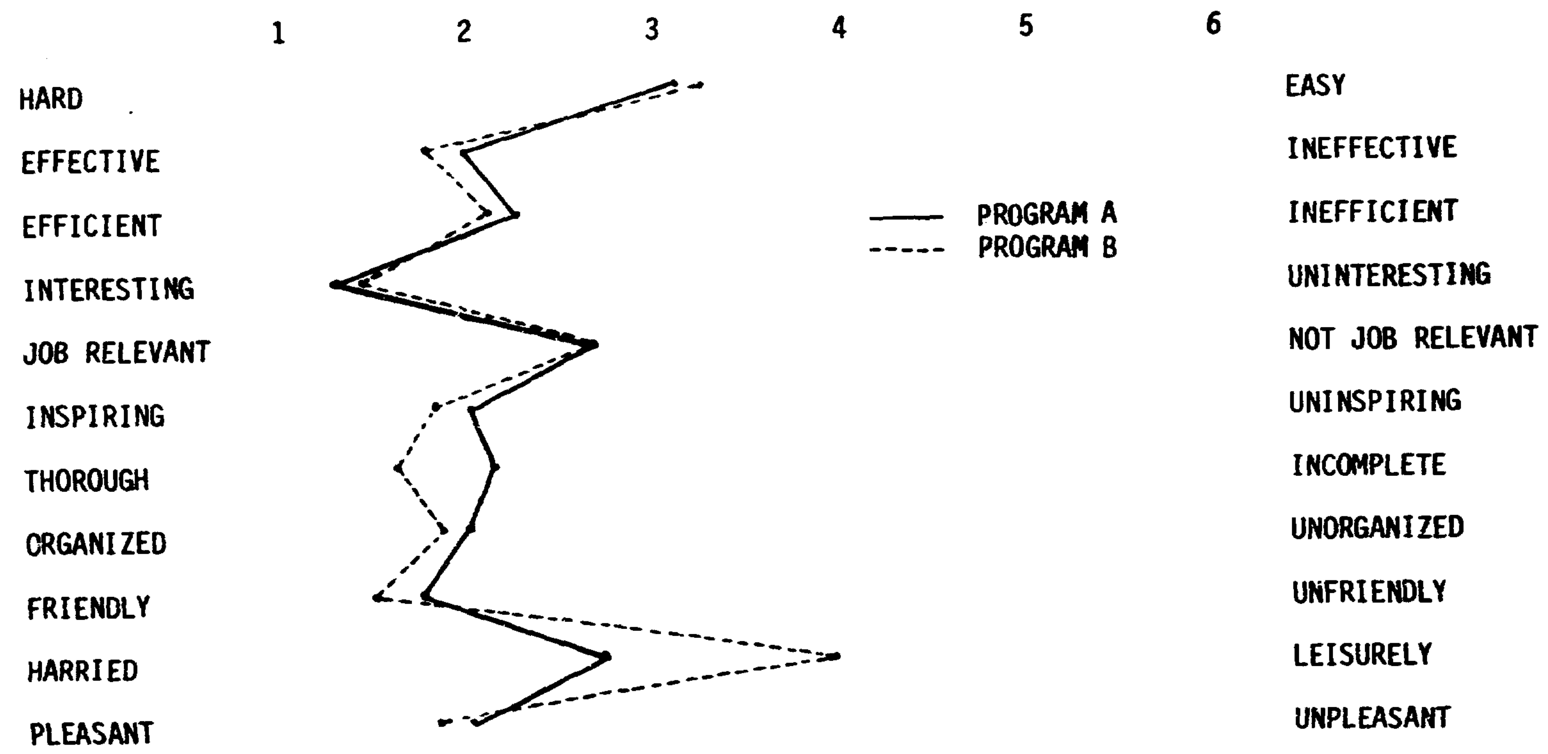


FIGURE 9.--MEAN RESPONSES TO STUDENT OPINION SURVEY ITEM 18(a) REGARDING FEELINGS TOWARD TRAINING RECEIVED IN THE AIRCRAFT.

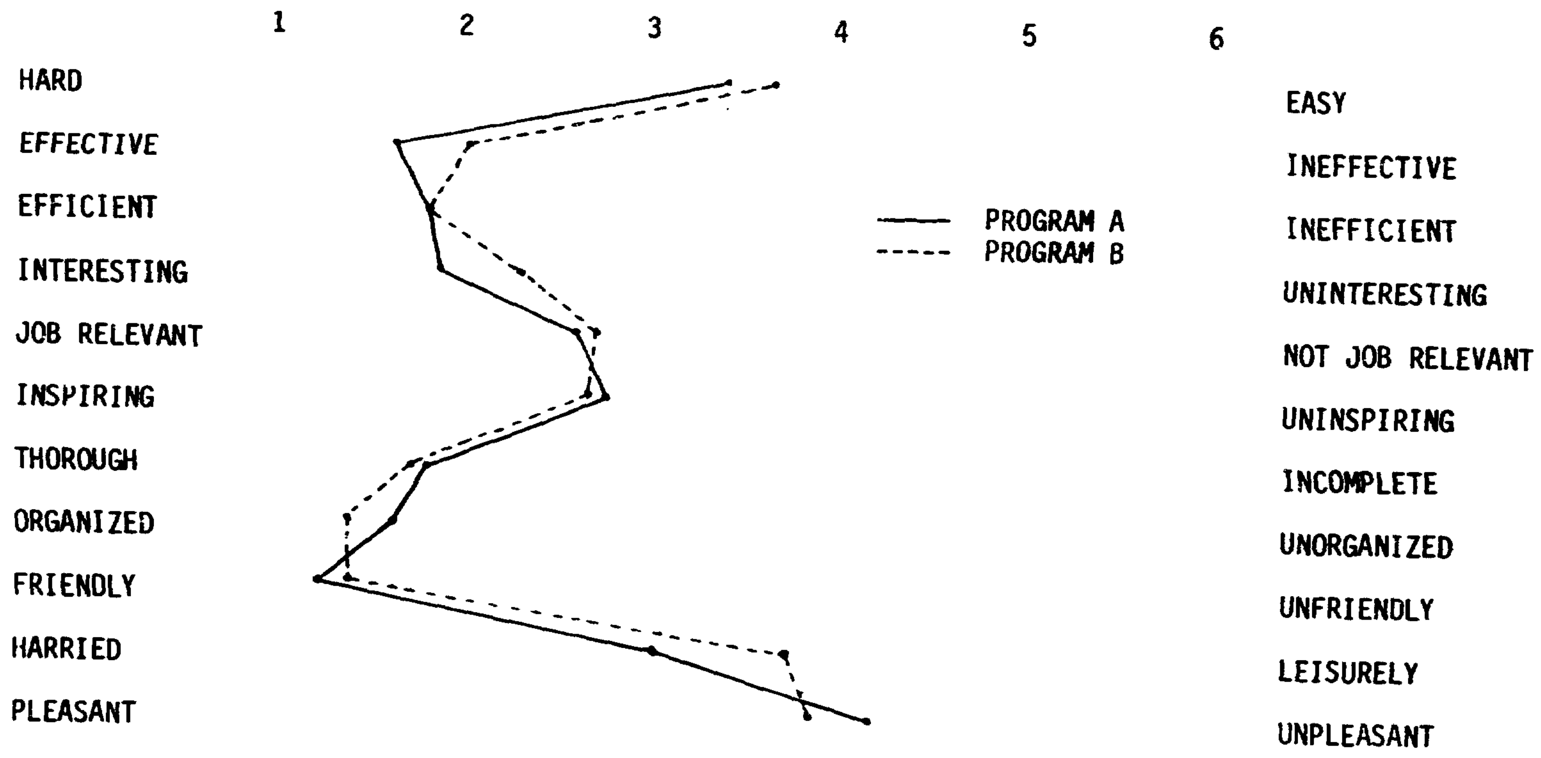


FIGURE 10.--MEAN RESPONSES TO STUDENT OPINION SURVEY ITEM 18(b) REGARDING FEELINGS TOWARD TRAINING RECEIVED ON THE GROUND.

The conclusion to be drawn is that students in both programs viewed the maneuvers as relatively easy to learn on the whole, and any overall differences, if present, are quite small.

Because the remaining items of the Student Opinion Survey did not lend themselves to meaningful combinations for analysis, t tests were run for each item separately. Only three ts were significant: (1) Program A students were more inclined to report that their supervisors believed that their training distracted them from their jobs ($p < .01$); (2) Program B students would have liked more frequent flights during training ($p < .05$); and (3) Program B students reported having less trouble remembering what they had learned on previous flights ($p < .05$). On these 3 and the remaining 16 general items on the Survey, reactions toward training were typically positive.

Before turning to the self-assessment data, it should be pointed out that the significant ts reported above, except for those concerned with maneuvers, related directly to the relative amount of distribution of training over time experienced by Programs A and B, respectively. Program B considered their aircraft training more leisurely, they were less distracted from their jobs, they would have liked more frequent flights, and they remembered more from one flight to the next.

SELF-ASSESSMENT DATA. The self-assessment data were of two kinds: (1) predictions of one's own performance on the fourth checkride in terms of numbers of errors the student expected to make on each of 29 maneuvers; and (2) self-evaluations in terms of numbers of errors each student thought he made on each of the 29 maneuvers during the fourth checkride. As explained earlier, these data were collected primarily for another purpose; but they also reveal something regarding the confidence each student had in himself, and, by implication, his assessment of the adequacy of training received.

In addition to the analyses of these data discussed earlier in this section, the means of pre-checkride predictions and of post-checkride self-evaluations were compared for the two programs on each of the 29 maneuvers. For prediction scores, Program B as a group predicted fewer errors for themselves than Program A did on each of the 29 maneuvers; and the difference was statistically significant ($p < .05$) for 12 of the 29 maneuvers. For post-checkride data, Program B's self-evaluations showed fewer mean errors on 27 of 29 maneuvers; and the differences from Program A were statistically significant for 9 of the 29 maneuvers.

The results of these analyses are generally consistent with those pertaining to reported difficulty in learning maneuvers which were discussed in the preceding section (Item 19 on the Student Opinion Survey). The results of the analyses are more clear-cut, however, and less ambiguous regarding perceptions of the value of training. Whereas one might have difficulty learning regardless of the quality of training, confidence that one can perform with few errors speaks directly to perceived quality of training. The data from self-assessments suggest that Program B students had more confidence in themselves. If so, it may be inferred that they also had more confidence in their training.

IV. CONCLUSIONS

The major findings of the present study are discussed in the following paragraphs. As in the Results section, the discussions are divided into four major segments: (1) training effectiveness, (2) training efficiency, (3) assessment of performance, and (4) perception of training.

1. TRAINING EFFECTIVENESS.

In general, with respect to the overall performance of students at the end of ground and flight training, there were no significant differences between Programs A and B. The academic performance of students in the two programs, as measured by the ground school final exam and the FAA Private Pilot-Airplane Written Test, did not differ. Nor were there any overall differences on the measures of flying proficiency taken at the end of flight training--i.e., the fourth PPDR checkride and the FAA Private Pilot-Airplane Flight Test.

When performance was considered with respect to the separate PPDR task subsets (I, II, and III) on the fourth checkride, however, certain patterns of differences did appear. To begin with, students in both programs tended to do better on tasks in Subset I than on tasks in Subset II, and better on tasks in Subset II than on those in Subset III. Students in Program B, however, made fewer errors, relative to students in Program A, on tasks in Subsets I and II, while students in Program A tended to make fewer errors on tasks in Subset III.

This interaction between programs and task subsets served to reduce or mask differences between the programs when overall checkride performance (i.e., performance summarized across all tasks) was considered. That is, the superiority of Program B on Subsets I and II was offset or counterbalanced by the superiority of Program A on Subset III. The finding of an interaction between task subsets and programs is not surprising, since the results of past research have indicated that the nature of the impact of different distributions of training tends to be specific to the characteristics of the tasks being learned (for discussion of relevant points, see Appendix A).

It may be possible that the more distributed training regimen of Program B is advantageous for the learning of tasks in Subsets I and II, which tend to be primarily psychomotor skill tasks. In contrast, Subset III tasks are much more heavily cognitive and procedural in nature, and the closer temporal relationship between flight training and checkride for Program A might be expected to result in a lesser amount of forgetting. Also, it is worth noting that the application of what is learned in the classroom to flight is of more direct nature for Subset III tasks, and the shorter time between classroom learning and checkride would also minimize the amount of forgetting for Program A students.

Such speculations notwithstanding, however, with respect to training effectiveness, it can be concluded that the different distribution of training time had no significant or practical impact on the overall academic or flight

performance of the students. Students in both groups clearly were able to perform well enough to meet the minimum requirements for their private pilot certificates at the end of their training. The differences in relative performance between programs on task subsets should be taken into consideration, however, when student pilot training is being planned.

2. TRAINING EFFICIENCY.

Training efficiency was assessed in three ways: (1) the number of flight and oral hours spent by students in various training activities, (2) the patterns of the students' progress through flight training as measured on the four checkrides; and (3) the patterns of progress of the students through ground school as measured on the six written quizzes.

Students in Program B received fewer total flight hours during their training than did students in Program A. This difference in total time was entirely due to a substantial difference in dual flight time; there was no such difference in solo flight time. Other significant differences in flight time, when they occurred, also favored Program B--i.e., students in Program B flew fewer hours prior to Checkrides 3 and 4. Thus, with respect to flight hours, it can be concluded that Program B was more efficient than Program A. Since the major difference was in dual flight hours, where instructor costs are added to flight costs, this difference in efficiency is of substantial practical importance.

The pattern of Program B tending to be more efficient is also apparent in measures of the flight progress of the students through the flight training programs--i.e., in the patterns of the PPDR scores obtained on the four checkrides. When significant differences were observed between programs on any of the task subsets, they were almost always in favor of Program B. Performance on Subset II, for example, was better for Program B on all three checkrides (2, 3, and 4) on which this subset was measured. Additionally, the performance of students in Program B was better on tasks in Subset I on three of the four checkrides (2, 3, and 4).[1] Thus, students in Program B tended to fly less, at least with their instructors, and tended to perform better at various flight checkpoints during the program. That is, they appeared to learn more rapidly, with less effort, during training.[2]

---

[1]As a possible exception to the trend that Progam B was more efficient, it was observed that the average performance of Program A was slightly better on Subset III (Checkrides 3 and 4), though this difference was not statistically significant.

[2]Before leaving the discussion of PPDR scores on the four checkrides, it should be noted that scores on the various task subsets (I, II, and III) usually improved across checkrides, indicating that students in both programs were learning to perform them better. This change in performance across checkrides demonstrates that the PPDR was sensitive to variation in an individual's proficiency over time. Thus, the utility of the PPDR for assessing retention (variance in proficiency across time) is also illustrated.

The relative efficiency advantage of Program B over A holds true only for flight training, however. When the pattern of academic performance on the six written quizzes during ground school was examined, it revealed that students in Program A scored higher than those in Program B on all quizzes, especially the last three. Thus, the patterns of progress differed between students in the two ground school programs. Students in Program B tended to perform less well during the ground school course, but at the end of training, as reported under training effectiveness, did just as well as students in Program A on the final ground school exam and the FAA written test. Whether this "catching up" was due to cramming or to their benefiting more from their flight instruction could not be determined. Nevertheless, the Program B students did catch up with the result that there was no difference between the groups on the two end-of-course academic tests.

In summary, distributing private pilot training over longer periods of calendar time appears to improve the efficiency of flight training to a certain degree, but may serve to lower the efficiency of ground school. It may well be possible to adapt private pilot training so as to take advantage of positive aspects of both concentrated and distributed training as they affect efficiency. Practice in flight skills could be distributed, for example, while blocks of ground training could be concentrated and provided at optimal points so as to permit integration of ground and flight instruction. It would appear that the only efficiency difference of practical consequence is that relating to the lesser average flight time received by the students in Program B. The approximate 10 percent reduction in flying hours of Program B over A is a matter of both financial and fuel savings concern.

3. ASSESSMENT OF PERFORMANCE.

Using the pre-flight questionnaires employed in this study, the students, taken as a group, were not able to predict the number of errors they would make on the fourth checkride. Some students, however, were better than others at predicting their performance. That is, their predictions correlated to a greater extent with their actual performance on checkrides than did the predictions of other students.

Similarly, as a general rule, the students were not able to evaluate their own performance after they had completed the fourth checkride. As with predicting, however, some students were better than others at evaluating their performance. In large part, these students were the same ones who were better at predicting their performance. Unfortunately, there was no way to identify beforehand which students would be better able to predict and evaluate their own performance.

The purpose of collecting these data was to develop a methodology for evaluating the capabilities of pilots to assess their own performance. Such capabilities are needed to identify accurately and efficiently the areas in which a certificated pilot feels he needs recurrent training. As such, the methodology was designed mainly to be employed in the second phase of the present study. The students will be given similar pre- and post-flight questionnaires before and after each of the checkflights that will be conducted in the later long-term retention phase (shown in Figure 2 in the Methods section). During

the second phase, determinations will be made of whether the students who were better able to predict and evaluate their performance can retain these capabilities over time. Patterns of change over time within these capabilities for all pilots will also be investigated.

In summary, the ability of certificated pilots to assess their own performance accurately remains to be demonstrated. Preliminary findings show that, as a general rule, student pilots are not able to predict or evaluate checkride performance. While some student pilots are able to predict and evaluate better than others, there is no way at present to determine beforehand which students have such capabilities. Research during the second phase of the present study will address these and other related issues in an attempt to gain a systematic understanding of the self-assessment problem.

4. PERCEPTION OF TRAINING.

Based on their general response to the Student Opinion Survey, the students in both programs felt very positive toward their flight training, with those in Program B being slightly more positive than those in Program A. Students in both programs also felt positive about their ground training, but less so than they did for flight training.

With respect to specific survey questions, only a few differences occurred between the responses of students in the two programs. As might be expected because of its concentrated nature, students in Program A felt that their flight training was more harried and that it distracted more from their job. Students in Program B would have preferred more frequent flight lessons, while students in Program A reported more trouble in remembering what was learned. While the reason for their trouble in remembering is unclear, it may have been related to the reduced training effectiveness and efficiency observed in Program A.

When asked to rate (on the Student Opinion Survey) the difficulty of the tasks that they learned, students in Program B consistently (on 26 out of 29 tasks) rated tasks as being less difficult when compared to the ratings of the students in Program A. Similarly, on the pre- and post-flight questionnaires, students in Program B consistently predicted that they would make fewer errors and, after the checkride, felt that they had made fewer errors (even though there was no overall difference between programs in actual performance on the fourth checkride). Thus, it can be concluded that students in Program B felt more confident in their flight training. As a group, they felt they had less difficulty learning to fly, and that they would and did do better on the fourth checkride. Flight check data tended to substantiate their view.

SUMMARY OF MAJOR CONCLUSIONS.

The major findings just discussed are summarized in Table 12. In general, these results suggest that the lengthening of private pilot training to spread out training expenses as these costs rise will not have a serious impact on the effectiveness of instruction. No significant differences were observed in overall performance of the students at the end of ground and flight training. Certain differences in effectiveness were observed with respect to particular

categories of tasks, however, and they should be taken into consideration in the conduct and evaluation of private pilot training. But, insofar as the Phase I results are concerned, there were no practical, comprehensive differences in instructional effectiveness between the two programs.

TABLE 12.--SUMMARY OF MAJOR RESULTS

	Findings
1. TRAINING EFFECTIVENESS	
A. Fourth flight checkride (PPDR)	1. No overall difference between programs.
	2. Fewer errors were made by students in both programs on Task Subset I than II, and fewer on II than III.
	3. Program B did better than A on Subsets I and II, but A did better than B on Subset III.
B. FAA Private Pilot-Airplane Flight Test	1. No overall differences between programs.
C. Ground school final exam	1. No overall difference between programs.
D. FAA Private Pilot-Airplane Written Test	1. No overall difference between programs.
2. TRAINING EFFICIENCY	
A. Flight and oral hours	1. Program B accumulated fewer total dual hours.
	2. Program B also accumulated fewer hours prior to Checkrides 1 and 3.
	3. There was a larger variance in flight hours among students in Program B, especially solo hours.

(Continued)

TABLE 12 (Continued)

	Findings
B. Flight checkrides (PPDR; Task Subset I)	1. No overall difference between programs.
	2. Performance of students in both programs improved across checkrides (1, 2, 3, 4).
	3. Program A did marginally better than B on the first checkride, but B did better on the other three checkrides, especially the third one.
C. Flight checkride (PPDR; Task Subset II)	1. Program B did better than A on three checkrides.
	2. Performance of students in both programs tended to improve over checkrides (2, 3, 4).
D. Six written quizzes	1. Program A did better than B across all quizzes, especially the last three quizzes.
3. ASSESSMENT OF PERFORMANCE	
A. Relation of pre-flight predictions to actual performance	1. As a general rule, students were not able to predict their performance. Some students, however, were better than others at predicting.
B. Relation of post-flight evaluations to actual performance	1. As a general rule, students were not able to evaluate their own performance. Some students, however, were better than others at evaluating.

(Continued)

TABLE 12. (Continued)

	Findings
4. PERCEPTION OF TRAINING	
A. Student Opinion Survey	1. In general, students in both programs felt positive toward flight training; those in Program B were slightly more positive.
	2. Students in both programs were less positive toward ground training than flight training.
	3. Students in Program A felt training was more harried and that it distracted them more from their job. They also felt they had more trouble remembering what was learned.
	4. Students in Program B would have preferred more frequent flight lessons.
	5. Program B reported less difficulty with learning most tasks (26 of 29 rated).
B. Self-assessment data	1. Students in Program B predicted they would make fewer errors on all tasks.
	2. Students in Program B also felt they had made fewer errors on most tasks (27 of 29 rated).

Whether training is distributed or concentrated does appear to have an impact on instructional efficiency. Students in the longer program flew fewer flight hours, particularly dual flight hours, than did those in the shorter program. Given the costs (and fuel consumption) associated with flight hours, especially dual hours, this finding is of substantial practical importance. Differences between programs could add up to as much as 10 percent of total training costs.

The increased efficiency of the longer program is also reflected in the patterns of student progress through flight training. When differences existed, students in the longer program tended to perform better on the four checkrides

administered periodically during training. A different trend appeared, however, when patterns of student progress through ground school training were assessed. In this case, students in the shorter program did better on the periodic written quizzes given during ground training. Thus, it would be beneficial to schedule ground and flight training segments at different rates to take advantage of positive aspects of concentrated and distributed training.

In agreement with observed differences on training efficiency, certain patterns appeared in the way students perceived their training. Students in the longer program felt slightly more positive toward their flight training, although they preferred to have flown more frequently. Students in the shorter program felt their flight training was more harried and that it distracted them more from their job. Additionally, students in the shorter program appeared to be less confident in their training than those in the longer program.

As previously discussed, full determination of the impact of different distributions of training time will be made in the second phase of the present study. Indeed, even though the first phase is of value in itself, it is during the second phase that the most crucial questions concerning the effects of training and experience distribution on the performance of certificated pilots will be investigated. Do differences in the distribution of training time affect retention of flying skills? Do differences in the rates of flying after certification influence retention of these skills, and, if so, which ones are affected most and how are they affected? What other factors influence retention of flying skill? Determination of the answers to these questions will aid in the development of effective and efficient pilot training/retraining programs and of procedures for their associated reviews of pilot proficiency. In short, such answers will aid in the development of better means for managing the skill maintenance problems of general aviation. The effort reported here provides both directly usable information in that regard and a baseline for evaluating results of the second phase skill retention study.

REFERENCES

Bilodeau, E. A. (Ed.) Principles of skill acquisition. New York: Academic Press, 1969.

Cessna Aircraft Company. Information manual, Skyhawk (Model 172N). Wichita, KS: Author, 1979.

Deese, J., & Hulse, S. H. The psychology of learning. New York: McGraw-Hill Book Co., 1967.

Eddowes, E. E., DeMaio, J. C., Pierce, B. J., Eubanks, J. L., Lyon, D. R., Killion, T. H., & Nullmeyer, R. T. Skills maintenance and reacquisition training research program: Tactical Air Command preliminary evaluation (Tech. Rep. AFHRL-TR-80-45). Brooks AFB, TX: Air Force Human Resources Laboratory, March 1981.

Federal Aviation Administration. Flight test guide, private pilot, airplane (Advisory Circular AC 61-54A). Washington, DC: Author, 1975.

Federal Aviation Administration. Private Pilot-Airplane Written Test guide (Advisory Circular EA-AC 61-32B). Washington, DC: Author, 1977.

Federal Aviation Administration. Flight training handbook (Advisory Circular AC 61-21A). Washington, DC: Author, 1980.

Gagne, R. M., & Bolles, R. C. A review of factors in learning efficiency. In E. Galanter (Ed.), Automatic teaching: The state of the art. New York: Wiley, 1959.

Gardlin, G. R., & Sitterley, T. E. Degradation of learned skills: A review and annotated bibliography (Boeing Document D180-15080-1). Seattle, WA: The Boeing Company, June 1972.

Greer, G. D., Smith, W. D., & Hatfield, J. L. Improving flight proficiency evaluation in Army helicopter pilot training (Tech. Rep. 77). Alexandria, VA: Human Resources Research Organization, May 1962.

Hollister, W. M., LaPointe, A., Oman, C. M., & Tole, J. R. Identifying and determining skill degradations of private and commercial pilots (Tech. Rep. FAA-RD-73-91). Washington, DC: Federal Aviation Administration, September 1973.

Howell, W. C., & Goldstein, I. L. Engineering psychology. New York: Meredith Corporation, 1971.

Kershner, W. K. The student pilot's flight manual. Ames: Iowa State University Press, 1979.

Lawther, J. D. The learning and performance of physical skills. Englewood Cliffs: Prentice-Hall, Inc., 1977.

McNemar, Q. Psychological statistics. New York: John Wiley and Sons, 1969.

Munley, F. Commuter airline safety: An analysis of accident records and the role of federal regulations. Washington, DC: Aviation Consumer Action Project, August 1976.

National Aeronautics and Space Administration. NASA Aviation Safety Reporting System: Seventh quarterly report (NASA-TM-78528). Washington, DC: Author, August 1978.

National Transportation Safety Board. Air taxi safety study (NTSB-AAS-72-9). Washington, DC: Author, September 1972.

National Transportation Safety Board. Special study - U.S. general aviation accidents involving fuel starvation, 1970-1972 (NTSB-AAS-74-1). Washington, DC: Author, April 1974.

National Transportation Safety Board. Special study - U.S. general aviation takeoff accidents: The role of preflight preparation (NTSB-AAS-76-2). Washington, DC: Author, March 1976.

National Transportation Safety Board. Special study - light twin-engine aircraft accidents following engine failures, 1972-1976 (NTSB-AAS-79-2). Washington, DC: Author, December 1979.

Naylor, J. C., & Briggs, G. E. Long-term retention of learned skills: A review of the literature (ASD-TR-61-390). Wright-Patterson AFB, OH: Air Force Systems Command, August 1961.

Prophet, W. W. Long-term retention of flying skills: An annotated bibliography (Tech. Rep. HumRRO-FR-ED[PJ-76-36). Alexandria, VA: Human Resources Research Organization, October 1976.

Prophet, W. W., & Jolley, O. B. Evaluation of the integrated contact-instrument concept for Army fixed wing flight instruction (Tech. Rep. 69-26). Alexandria, VA: Human Resources Research Organization, December 1969.

Schendel, J. D., Shields, J. L., & Katz, M. S. Retention of motor skills: Review (ARI Technical Paper 313). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978.

Seltzer, L. Z. A study of the effect of time on the instrument skill of the private and commercial pilot (Tech. Rep. FAA-DS-70-12). Washington, DC: Federal Aviation Administration, April 1970.

Shelnutt, J. B., Childs, J. M., Prophet, W. W., & Spears, W. D. Human factors problems in general aviation (Tech. Rep. FAA-CT-80-194). Washington, DC: Federal Aviation Administration, July 1980.

Sitterley, T. E., Zaitzeff, L. P., & Berge, W. A. Degradation of learned skills--effectiveness of practice methods on visual approach and landing skill retention (Boeing Document D180-15082-1). Seattle, WA: The Boeing Company, October 1972.

Smith, F. J., Flexman, R. E., & Houston, R. C. Development of an objective method of recording flight performance (Tech. Rep. 62-15). Lackland AFB, TX: Air Training Command, Human Resources Research Center, December 1952.

Winer, B. J. Statistical principles in experimental design (second edition). New York: McGraw-Hill, 1971.

Wright, R. H. Review of behavioral science research data relevant to Army proficiency flying programs (HumRRO Consulting Report). Ft. Rucker, AL: Human Resources Research Organization, Division No. 6., April 1969.

Wright, R. H. Retention of flying skills and refresher training requirements: Effects of non-flying and proficiency flying (HumRRO Tech. Rep. 73-32). Alexandria, VA: Human Resources Research Organization, December 1973.

APPENDIX A

DISCUSSION OF PAST RESEARCH

A considerable amount of psychological research has been devoted to the study of (1) the impact of different distributions of training time on the acquisition of complex skills, and (2) factors influencing the retention of such skills. Since comprehensive reviews of this research are available (and are referenced below), it will not be reviewed here. Rather, the following sections discuss the implications of the results of this research for the design of the present study and for the interpretation of its findings.

DISTRIBUTION OF TRAINING TIME.

Psychologists interested in human learning have long studied the impact of different distributions or schedules of practice on the acquisition and retention of psychomotor and other skills. Determination of the manner in which different strategies of scheduling practice influenced learning provided data for developing fundamental theoretical constructs concerning how humans learn. As such, reviews of learning research and theory usually contain reviews of numerous studies devoted to this topic (e.g., Bilodeau, 1969; Deese and Hulse, 1967; Naylor and Briggs, 1961).

In addition to theoretical implications, research on the influence of practice on skill acquisition has also been motivated by applied considerations. Behavioral scientists interested in developing training programs for a variety of jobs and athletic skills, for example, have conducted research to determine how this training might best be scheduled. Thus, information concerning the influence of distributions of practice can also be found in the applied research literature concerned with such training (e.g., Gagne and Bolles, 1959, pp. 26-48; Howell and Goldstein, 1971; Lawther, 1977).

It is difficult, however, to use the results of this past research, applied or basic, to develop general guidelines for scheduling flight training. In part, applicability of the results of this research is limited by the frequent use of simplistic and, at times, highly artificial tasks in these past studies. While use of such tasks enables a substantial amount of control in an experiment, it also reduces the generalizability of study results--given a lack of theories for relating such tasks to more complex tasks such as those involved in flying. Furthermore, the nature of experimental conditions studied in past efforts is quite restricted when compared with conditions involved in flight training. The length of the interval between practice sessions, for instance, was often a matter of minutes, as opposed to much longer intervals characteristic of flight training, and experimental training programs were almost always far less extensive and disruptive of other ongoing activities than is private pilot training.

Nevertheless, the results of many of these experiments are of substantial value in identifying general factors inherent in different strategies for scheduling practice that serve to facilitate or hinder learning. Research has

shown, for example, that one of the advantages of concentrated practice, relative to more distributed practice, is that it minimizes, in certain situations, forgetting between learning sessions. Concentrated practice also usually enables the learner to build higher skill levels over a shorter calendar time, often increasing the learner's motivation to devote more effort to training. On the other hand, concentrated practice on some tasks leads to fatigue that reduces the efficiency of learning. It can also reduce the amount of time a student has to prepare for a training session, and increase the potential for conflict between preparatory activities and other activities outside training (e.g., job, home life).

Additionally, concentrated training also can reduce the amount of time a student has to "sort out" various aspects of skill performance so that similar components will not be confused with each other. To the extent that motor skills must be coordinated with visual cues, judgments, and decisions as they are during flight, the likelihood of confusion is increased. Generally, for skills of a given complexity, the confusion can be reduced to the extent that each separate skill is mastered, or sufficient time elapses between practice sessions for the confusion to dissipate.

The relative advantages of concentrated training (e.g., less chance of forgetting, less calendar time needed to achieve higher skill levels) and of distributed training (e.g., less possibility of fatigue, more time for preparation, less chance of confusion across training sessions) depend to a large extent on the types of tasks which are learned. For example, tasks with less internal structure, such as procedural tasks, tend to be more prone to being forgotten. Thus, distributed practice of procedural tasks may not be as efficient as more concentrated practice in which there is less chance for students to forget what they have learned in earlier sessions.

These general findings of past research have several implications for the present study. The existence of variation in the impact of distributed training across different types of tasks, for example, means that the measures used in the study had to be sensitive to possible task by training schedule interactions. That is, the measures had to be able to discriminate if students in the shorter flight training program learned some tasks, but not others, more efficiently than students in the longer program (and vice versa). Global measures of overall flight performance would not allow such differences to be detected.

Additionally, measures were needed that enabled differences in patterns of training progress in the two programs to be described. Such assessments would provide information to aid in the interpretation of why the performance of students in the program differed. Similarly, measures were needed that assessed the student's attitudes toward the training they received and its impact on their life (e.g., the amount it distracted from their normal job). Such measures would also aid in understanding any performance differences that occurred between students in the two experimental programs.

RETENTION OF FLYING SKILL.

A recent study, designed to identify major human factors issues in general aviation, concluded that the loss of once proficient flying skills is one of

the most critical performance problems besetting the general aviation pilot community (Shelnutt, Childs, Prophet, and Spears, 1980). Indications of the current seriousness of this problem can be obtained from the review of general aviation accidents and incidents. While deficiencies within the data describing these accidents and incidents limit their use,[1] several in-depth reviews of certain types of these mishaps have concluded that improvements were needed in recurrent pilot training and also in recurrent reviews of pilot proficiency to prevent future accidents attributable to skill retention problems (e.g., Munley, 1976; National Aeronautics and Space Administration, 1978; National Transportation Safety Board, 1972; 1974; 1976; 1979).

Additional indications of the retention problem can be found in two studies that have investigated the loss of flying skills by private pilots in the years after their certification (Hollister, LaPointe, Oman, and Tole, 1973; Seltzer, 1970). Although confounded by certain methodological limitations (which will be discussed later), both of these studies found serious deficiencies in certain types of flying skills. In both cases, these deficiencies were related, to a moderate degree, to the number of years since the pilot had been certificated. That is, certain flying skills tended to decline as the number of years since certification increased.

Thus, in a sense, the goal of the present study is to aid in the solution of the current skill retention problem as well as to prevent it from becoming worse as private pilots fly less. To accomplish this goal, it will be necessary to produce systematic guidance that will aid in the identification of (1) skills most likely to degrade over time, and (2) factors affecting the way in which they degrade. Such guidance will enable private pilots to anticipate their recurrent training needs. In will also enable them (and their instructors) to structure reviews of their proficiency (e.g., the Biennial Flight Review) so that these reviews focus on skills most likely to have degraded.

While such guidance is not presently available, considerable information can be obtained from past human factors and basic psychological research concerning requirements for this guidance, and how the guidance can be developed. The study of retention or, conversely, the forgetting of skills, has long been a subject of research, dating back to the turn of this century. Much of the early research was concerned with verbal behavior and simple motor behavior (Naylor and Briggs, 1961). While the results of this research are not of direct relevance to the present study, these studies provide the basic theoretical foundation for modern work which has dealt with more complex skills.

Many of these more recent studies represent attempts by the military and the National Aeronautics and Space Administration to develop empirical data bases and analytical models that could be employed in the development of recurrent training programs for pilots and astronauts. As such, much of this work is relevant to goals of the present project. Several reviews of this research are available. Prophet (1976), for example, has reviewed research specifically concerned with flying skill retention, while Schendel, Shields, and Katz (1978) reviewed research concerned with more general issues of skill

[1]As described in Shelnutt, Childs, Prophet, and Spears (1980).

retention. Additionally, Eddowes et al. (1981) reviewed a recent large scale flying skill retention study, the Skills Maintenance and Reacquisition Training Research Program, which was conducted to support the development of improved continuation training programs in the U.S. Air Force. These reviews and others (e.g., Gardlin and Sitterley, 1972; Wright, 1969) have covered the issues well, so past research on flying skill retention will not be reviewed here. Rather, selected major findings of this research, which directly influenced the planning of the present study, are summarized below.

Perhaps the most consistent finding of previous studies of forgetting is that the retention of a skill is a negatively accelerated function of the length of time since the skill was last performed. That is, the longer the time without practice of skill, the greater the degradation of the skill. Unfortunately, the specific pattern of forgetting in a given situation is a function of a number of different factors. Thus, in order to be able to predict when a skill will degenerate to unacceptable levels, it is necessary to identify the factors operating in the situation being investigated and to determine their specific impact on skill loss. Several general categories of such factors have been identified in past research. Those of interest with respect to the objectives of the present study concern (1) the nature of the original learning--i.e., how well a task was learned and the conditions under which learning occurred; and (2) the characteristics of the tasks being performed.

<u>DIFFERENCES IN ORIGINAL TRAINING</u>. The most significant factor influencing the retention of flight skills is the level to which they are learned originally (Prophet, 1976). Simply put, the greater the mastery during original training--or at any time prior to periods of non-practice--the higher performance will be after periods of non-practice. The dominance of mastery has two major implications for the methodology of the present study. First, when possible, studies of flight skill retention should include assessments of the original level of skill attained by pilots during their initial training for certification. Thus, subsequent measures of their performance can be compared directly with their original level of learning.

Studies which permit such comparisons, referred to by psychologists as "longitudinal" studies, have several advantages when compared to so-called "vertical" or cross-sectional studies in which the performance of a group of pilots with different lengths of time since certification is measured. In the vertical study, for example, differences in performance between pilots are attributed in part to differences in retention of skills. The assessment of these differences are confounded, however, by unknown variation in performance due to individual differences in the original level of learning. Given these differences, it is impossible to quantify the exact relationship among any factors of interest--e.g, task characteristics, or the amount of flying since certification--and actual retention of skills to perform different tasks.

Such confounding has reduced the value of the only two previous studies of private pilot flying skill retention (Hollister et al., 1973; Seltzer, 1970). While both of these studies provided evidence that skill retention is a problem for many private pilots, the interpretation of their results is limited by the lack of measurement of the original level of learning. In both studies, for example, the extent of the skill retention problem in general

aviation was revealed by the fact that the majority of the private pilots who participated in the studies were judged to be deficient with respect to at least some of the tasks that were tested. The extent of their deficiencies was correlated to some degree with the amount of flying they had done since certification and the recency with which they had flown relative to their testing during the research. Interpretation of these correlations is made uncertain, however, by the lack of information concerning original level of learning.

The second consideration implied by the dominance of original level of learning as a skill retention factor relates to the importance of initial training for retention. Since how well an individual learns a task largely determines how well he will retain it, factors influencing the effectiveness of initial training also affect skill retention. Furthermore, how a skill is learned may also affect how well it is maintained. Certain instructional practices may, for example, foster retention of skills better than other approaches, even though they may both result in the same apparent level of learning originally. Thus, the conditions for learning, as well as how well a pilot initially learns a skill, may be important in retention.

TASK CHARACTERISTICS. The retention of different flight tasks also varies with respect to the characteristics of the tasks. For example, tasks with a high degree of internal organization, such as flight control tasks, tend to be better retained than those with less internal organization, such as many procedural tasks (Prophet, 1976). Thus, performance of instrument procedures tasks tends to degrade faster than that of contact tasks (Sitterley, Zaitzeff, and Berge, 1972; Wright, 1973).

The existence of differences in the retention of various tasks has two major implications for the present study. First, the differences require that pilot performance be measured on individual tasks that are of interest. As such, global measures of flying proficiency are of little value--e.g., a single general rating of pilot proficiency or use of only a small number of dimensions. Moreover, given practical constraints, all tasks performed by private pilots cannot be measured. Thus, care must be taken to select a representative sample of tasks. Second, to aid in the interpretation of the results of research on skill loss, data describing errors in task performance need to be of sufficient detail to enable understanding of why the errors occurred. Such understanding is necessary to the determination of why the skill of a pilot to perform certain tasks degrades in the manner it does.

In summary, a considerable amount of research has been devoted to the study of (1) the influence of different distributions of training time on instructional effectiveness and efficiency, and (2) the impact of different factors on the retention of complex skills. While such research does not provide direct guidance concerning the problems addressed in the present study, they do provide considerable information which can guide both the design of a study and the interpretation of its results.

APPENDIX B

GROUND AND FLIGHT TRAINING SYLLABI

GROUND SCHOOL TRAINING SYLLABUS

LESSON 1

TOPIC:

Course Introduction
Aircraft Types
Aircraft Construction
Theory of Lift
Force Relationships
Three Axes
Flight Dynamics--Relation of
  Four Forces to Four Basic Flight Maneuvers
Aircraft Stability
Engine - Propeller Turning Effects

PERFORMANCE OBJECTIVES:

Name and locate major components
Compare aircraft types
Define angle of attack and stall
Describe theory of lift
List the four forces
Relate controls to aircraft movement
Describe four basic flight maneuvers
Define stability
Describe turning forces

LESSON 2

TOPIC:

Quiz 1: Aerodynamics
Flight Control Systems and Flight Instruments: Mag. Compass, Outside Air
  Temperature
Pitot-Static System and Gyroscopic Instruments
Engine Operation; Oil System; Fuel System; Electrical System
Airport Operations

PERFORMANCE OBJECTIVES:

Describe flight control systems
Account for magnetic compass errors
Define standard atmosphere
Define five types of altitude
Define three types of airspeed
Describe Airspeed Indicator color code
Describe gyroscopic instruments
State engine operating principles

LESSON 2 (Continued)

Compare two basic fuel systems
State function and location of electrical components
Interpret standard airport marking and lighting symbology
Describe traffic pattern

LESSON 3

TOPIC:

Operating Near Other Aircraft
Airport Air Traffic Control
Airport Communications
Aircraft Stability and Control
Determining Gross Weight and C.G. Location
Weight and Balance Computations
Basic Laws Relating to Aircraft Performance

PERFORMANCE OBJECTIVES:

Describe vortex turbulence characteristics and avoidance procedures
Describe basic ATC services at airport
Define load factor
Relate loading condition to stability and performance
Determine loaded aircraft gross weight and C.G. location
List standard values for passenger, fuel, and oil weights
Determine loading condition using graphic and tabular methods
Describe density altitude concept
Compute pressure altitude and density altitude
Describe factors affecting general aircraft performance

LESSON 4

TOPIC:

Takeoff Performance
Climb Performance
Cruise Performance
Landing Performance
Characteristics of Atmosphere
General Circulation
Air Masses
Condensation
Precipitation
Stability and Cloud Types
Quiz 2: Airport Operations, Weight and Balance

LESSON 4 (Continued)

PERFORMANCE OBJECTIVES:

Compute takeoff performance
Define, compare, and compute best rate of climb and best angle of climb airspeeds
Describe factors affecting takeoff and climb performance
Compute various cruise performance characteristics
Describe techniques of maximizing range and endurance performance
Compute landing performance
Describe factors affecting cruise and landing performance
Demonstrate ability to calculate performance limitations and understand factors affecting performance
Describe three-cell circulation model
Describe global circulation model
Classify clouds and identify associated weather, if any
State relationship between moisture, temperature, and stability
Define a temperature inversion and state its significance

LESSON 5

TOPIC:

Pressure Systems
Fronts and Associated Weather
Weather Hazards
Weather Reports and Forecasts
Quiz 3: Aircraft Performance

PERFORMANCE OBJECTIVES:

Locate source regions and list characteristics of their associated air masses
Relate wind and pressure
List and define 2 types of pressure systems
Define pressure gradient
Describe the various fog formation processes
List factors necessary for thunderstorm development
Define mountain wave
Compare rime and clear ice
Read and interpret aviation hourly weather reports
Read and interpret terminal forecasts
Read and interpret area forecasts
Read and interpret winds aloft forecasts
Compare and read SIGMETS, AIRMETS, and PIREPS

LESSON 6

TOPIC:

Weather Charts
Obtaining and Coordinating Weather Information
Weather Avoidance Procedures
Reporting Weather in Flight

PERFORMANCE OBJECTIVES:

Decipher state model
Interpret all information on the surface analysis chart
Interpret information on the weather depiction chart
State frequency and describe purpose of EWAS
Compare and describe transcribed weather broadcasts, scheduled and unscheduled broadcasts
Describe procedure for obtaining in-flight weather advisories
Define CAT (Clear Air Turbulence)
Describe procedure for avoiding thunderstorms
Define four classifications of ice accumulation

LESSON 7

TOPIC:

Definitions and Abbreviations in FARS
Pilot Certification Procedures
Airspace Utilization
Quiz 4: Aviation Weather

PERFORMANCE OBJECTIVES:

Compare category, class, and type as each relates to aircraft and airmen certification
Define controlled airspace, night time, flight time, ceiling, and airport traffic area
List eligibility requirements for student and private pilots
State expiration date of each medical certificate
State limitations of private pilot certificate
Define PCA, CCA, controlled areas, transition area, control zones, airport traffic area, and AAAs

LESSON 8

TOPIC:

Operating Rules and Regulations--General
Operating Rules and Regulations--Flight Rules
Aircraft Maintenance

LESSON 8 (Continued)

Accident-Reporting Procedures
Overview of Navigation Methods: Pilotage, Dead Reckoning, and Radio Navigation

PERFORMANCE OBJECTIVES:

Demonstrate ability to apply regulations to specific flight situations
State date for annual inspection
State requirements for 100 hour inspection, include time requirements and limitations
Name person responsible for maintenance records and list of records
Define operator, serious injury, and substantial damage
State when report must be made
State when immediate notification of accident must be made and to whom
Define three approaches to navigation

LESSON 9

TOPIC:

Navigation Computer: Slide Rule Side
Navigation Computer: Wind Side

PERFORMANCE OBJECTIVES:

Locate and name each of the scales on the slide rule side of the computer
Solve for time, speed, and distance when any of the other 2 are provided
Solve for amount of fuel, rate of consumption, or endurance when any of the other two are provided
Compute true altitude
Compute true airspeed
Compute density altitude
Use all conversion scales
Solve for heading correction to parallel or return to desired track when blown off course
Perform complex navigation problems
Compute time and distance to station
Construct the wind triangle
Define wind correction angle

LESSON 10

TOPIC:

Navigation Computer: Wind Side
Aeronautical Charts
Chart Orientation
Aeronautical Chart Interpretation
Navigational Plotter
Quiz 5: FAR's

LESSON 10 (Continued)

PERFORMANCE OBJECTIVES:

Name and locate the components of the wind side of the navigation computer
Use the computer to solve wind triangles--both preflight and inflight
Demonstrate ability to use computer to perform all required computations
Compare various aeronautical charts
Compare Mercator with Lambert Conformal chart projections
Specify directions in relation to compass rose
Define latitude and longitude
Locate position on chart with geographic coordinates
Define magnetic variation and use of isogonic lines to determine its value
Compare and indicate specific advantage or use of various aeronautical charts
Interpret symbols on all charts (Sectional and WAC)
Use navigation plotter to measure distance between and direction between any two places on the sectional chart

LESSON 11

TOPIC:

Dead Reckoning
Flight Log Prep
Flight Log Usage
Overview of VOR Navigation
Introduction to VOR
VOR Navigation

PERFORMANCE OBJECTIVES:

Use computer, plotter, and chart to determine compass heading and elapsed time estimates
Complete flight log for given cross-country flight
Demonstrate ability to use D.R. navigation technique
Describe principles of and operation and limitations of VOR navigation
Define VOR, TACAN, DME, and VORTAC
Describe sectional chart symbology for each
Describe VOR receiver components
Locate position of aircraft in relation to station using VOR display

LESSON 12

TOPIC:

VOR Navigation
DME and Area Navigation
ADF Navigation
Radio Navigation Practice Problems

LESSON 12 (Continued)

PERFORMANCE OBJECTIVES:

Use VOR to intercept and track radials
Explain cross-check procedure and VOR usage
Describe principle of operation and limitations and usage of DME and Area Navigation systems
Describe principles of operation and limitations and usage of ADF systems
Apply various radio navigational techniques to cross-country problems

LESSON 13

TOPIC:

Flight Communications
ATC Procedures

PERFORMANCE OBJECTIVES:

Demonstrate ability to use all appropriate radio aids in solving navigational problems
Determine FSS communications frequency from sectional charts data block
State the important FSS frequencies and their use
Define unicom and state its purpose and compare with multicom
State standard Emergency Frequency and state procedures for using it
Compare ASR with PAR radar
State use of ATCRBS
List six advantages of secondary radar
Name and locate the typical components of the transponder
Define phraseology unique to transponder operation
List and state use of discrete transponder codes
Describe various radar services

LESSON 14

TOPIC:

Publications: The Airmans Information Manual
The Advisory Circular System
Aeromedical Topics, Respiratory System Limitations and Dysfunction
Sensory Limitations
Effects of Drugs and Alcohol
Quiz 6: Radio Navigation

PERFORMANCE OBJECTIVES:

Name the basic parts plus the supplement to the AIM; state use of each, and frequency of issue
Decipher airport directory and facility information

LESSON 14 (Continued)

Locate and interpret Notam Information
Use AIM as reference to answer appropriate questions
Describe nature of advisory circulars
Discuss cause of hypoxia; list symptoms and methods of prevention
Discuss hyperventilation: list causes, symptoms and recovery techniques
Describe various sources of sensory confusion and degradation
Discuss likely effects of drug and alcohol consumption

LESSON 15

TOPIC:

Comprehensive Flight Planning and Execution
Course Review
Final Exam

PERFORMANCE OBJECTIVES:

Prepare comprehensive planning for hypothetical VFR cross-country flight, using all material previously discussed in body of course
Resolve any unanswered question and prepare for final exam
Demonstrate ability to apply skill, knowledge acquired, and skills developed during this course

PRIVATE PILOT FLIGHT TRAINING SYLLABUS

PREREQUISITES FOR ENROLLMENT.

The student must possess a valid Student Pilot's Certificate and hold at least a Class III medical certificate.

FLIGHT TRAINING COURSE OBJECTIVES.

The student will obtain the necessary aeronautical skill and experience toward meeting the requirements for a Private Pilot Certificate with an airplane category rating, and a single engine land class rating.

FLIGHT TRAINING COURSE COMPLETION STANDARD.

The student has demonstrated through flight tests and records that he/she has the necessary aeronautical skill and experience to successfully complete all requirements for a Private Pilot License.

PHASE I - PRESOLO

OBJECTIVE

The student will be instructed in the basic flying procedures and skills necessary for the first solo flight.

STANDARDS

This phase will be complete when the student satisfactorily passes the Phase I check and is able to conduct solo flights safely.

LESSON 1 - ORIENTATION

Objective: To familiarize the student with the course objectives, training facilities, student/instructor relationship, required course materials, training schedule procedures and record keeping procedures.

Standards: At the completion of this lesson, the student should understand the course objectives, training schedule procedures and record keeping procedures. The student should also have in his/her possession all required course materials and know what training facilities are available and the location of those training facilities.

LESSON 2 - PREFLIGHT AND GROUND OPERATIONS

Objective: The student will be introduced to the appropriate regulatory requirements of FAR Part 1-61-91. He/she will also be introduced to the proper procedures to conduct a preflight inspection of the training aircraft and the proper ground safety precautions.

Standards: At the conclusion of this lesson the student should be able to use the FAR's to determine appropriate information, have a working knowledge of the various parts of the aircraft for preflight purposes, and a thorough knowledge of the ground safety requirements.

LESSON 3 - AIRCRAFT FAMILIARIZATION

Objective: The student will become familiar with the training aircraft both by observing an actual flight and by receiving his/her first flight instruction in an airplane. The student will both observe and receive instruction in the basic flying maneuvers.

Standards: At the conclusion of this lesson, the student should be able, with assistance, to determine the aircraft to be in airworthy condition by a proper preflight inspection, properly startup and shutdown the aircraft, make engine run-ups, follow proper radio procedures, maintain altitude with ± 200 feet, heading within ± 20 degrees and recognize proper aircraft flight attitudes. He/she should also follow established ground and airport safety procedures.

LESSON 4 - SLOW FLIGHT AND STALLS

Objective: The student will receive instruction in controlling the aircraft at both reduced airspeeds and minimum airspeeds, with and without flaps. The student will also receive instruction in the recognition and proper recovery from both imminent and full stalls that may occur from normally anticipated flight attitudes.

Standards: At the conclusion of this lesson, the student should be able to properly control the aircraft with reduced airspeeds, from cruise down to minimum speed both with and without flaps. He/she will also be required to properly initiate, recognize, and recover from imminent and full stalls; maintain altitude within $\pm$ 150 feet, heading within $\pm$ 20 degrees, airspeed within $\pm$ 10 mph. Recovery from stalls should be made with little or no loss of control and a minimum loss of altitude.

LESSON 5 - GROUND REFERENCE MANEUVERS

Objectives: To teach the student to maneuver the aircraft over or around a predetermined ground path at an approximate traffic pattern altitude. The student will be taught to properly compensate for wind drift while dividing his attention inside and outside the aircraft.

Standards: At the conclusion of this lesson, the student should be able to properly select ground references and maneuver the aircraft in relation to these references. The student should accomplish these maneuvers with coordinated turns, smooth control pressures, and proper division of attention while maintaining altitude within $\pm$ 100 feet and airspeed within $\pm$ 10 mph.

LESSON 6 - TRAFFIC PATTERN OPERATIONS

Objective: To ensure the student has a thorough understanding of airport traffic patterns and procedures at both controlled and uncontrolled airports. To teach the student proper airport entry and departure procedures as well as proper communications procedures. The student will be taught to accomplish takeoffs and landings under all normally anticipated conditions, to include traffic pattern emergencies.

Standards: At the conclusion of this lesson, the student will be expected to safely takeoff and land the aircraft, unassisted, under all normally anticipated conditions. He/she will be expected to accomplish this while observing proper traffic pattern procedures, collision avoidance procedures, and communication procedures and to respond properly to emergency situations.

LESSON 7 - BASIC AIRWORK AND TRAFFIC PATTERN REVIEW

Objectives: This lesson will be used as a comprehensive review of the subject matter covered previously. Emphasis will be placed on the individual student's weak areas in preparation for the Presolo Phase Check.

LESSON 7 (Continued)

Standards: At the completion of this lesson, the student must display a thorough understanding of all previously learned procedures and have attained the required level of safety and competence to perform each maneuver with no assistance from the instructor.

LESSON 8 - PRE-SOLO PHASE CHECK

Objective: To determine by an oral exam and a flight check that the student has the necessary knowledge and competence to safely solo an airplane and progress to the next phase of training in this curriculum.

Standards: The student must demonstrate his/her knowledge and competence to safely solo the airplane by maintaining altitude within ± 100 feet, heading within ± 10 degrees, airspeed within ± 10 mph, maintain coordinated control of the aircraft, and demonstrate proper execution of any Phase I maneuvers or procedures checked.

LESSON 9 - SUPERVISED SOLO

Objective: During this lesson, the student will accomplish his/her first supervised solo flight if they have successfully passed the Phase I check and displayed the required level of safety and skill.

Standards: The student must display his/her continued ability to successfully perform safe and competent solo flight.

PHASE II - BASIC PILOT OPERATIONS

OBJECTIVE

The student will receive additional instruction in the basic flying maneuvers, receive an area checkout, be introduced to basic attitude instrument flying, VOR work, and maximum performance takeoffs, landings, and maneuvers. He/she will also receive directed solo practice of those maneuvers.

STANDARDS

This phase will be complete when the student has demonstrated to his/her flight instructor that they have a thorough understanding of the basic flight maneuvers, and has the knowledge and skill to safely practice those maneuvers and progress to the next phase of training in this course.

LESSON 10 - BASIC FLYING AND AREA CHECKOUT

Objective: To provide the student with the knowledge and understanding of the basic flying maneuvers and local area orientation so that he/she can safely practice those maneuvers within the designated practice areas.

Standards: The student must display the proficiency and competence required to make repeated solo flights, for the purpose of practicing the required maneuvers, within the designated practice areas.

LESSON 11 - BASIC ATTITUDE INSTRUMENT AND VOR ORIENTATION

Objective: The student will be shown the correlation between flying the aircraft by visual references and by flying the aircraft with instrument references and indications. He/she will also be introduced to VOR work; to include VOR orientation and tracking procedures.

Standards: At the completion of this lesson, the student should have a basic understanding of controlling the aircraft by use of the flight instruments to achieve basic aircraft attitudes and maneuvers. He/she should also be able to orient themselves to a VOR station and to fly to that station.

LESSON 12 - MAXIMUM PERFORMANCE TAKEOFFS AND LANDINGS

Objective: To instruct the student in the techniques used to achieve the maximum performance of the aircraft in taking off and landing in short or soft field conditions. The student will also be instructed in obtaining this performance data from the aircraft manual.

Standards: This lesson will be complete when the student can use the available information to determine aircraft performance and can perform the required takeoffs and landings under all normally anticipated conditions.

LESSON 13 - NIGHT OPERATIONS

Objective: During the lesson, the student's ability should be developed to a level that would enable him/her to make solo night flights within the local practice area and airport traffic area. The student will receive instruction in such areas as: night vision, night orientation, judgment of distance, use of cockpit, navigation, landing lights, and emergency night procedures. The airport and runway lighting system will also be discussed.

Standards: The student will have successfully completed this lesson when he/she displays the ability to maintain orientation in the local flying area and traffic pattern, can accurately interpret aircraft and runway lights, and has satisfactorily made 5 takeoffs and landings as the sole manipulator of the flight controls.

LESSON 14 - PROFICIENCY REVIEW

Objective: The student will receive additional instruction in those maneuvers or procedures in which he/she has shown a weakness or lack of understanding.

Standards: At the completion of this lesson, the student must have achieved a level of skill that will allow him/her to progress to the next phase of training.

PHASE III - CROSS-COUNTRY FLIGHT OPERATIONS

OBJECTIVE

The student will be instructed in the conduct of cross-country flights in an airplane using: pilotage, dead reckoning, and radio navigation. He/she will also receive instruction in operations within the ATC environment under VFR conditions.

STANDARDS

This phase will be complete when the student has demonstrated through a phase check, solo cross-country flight, and records that he/she can safely conduct solo cross-country flight in an airplane using pilotage, dead reckoning, and radio navigation under VFR conditions.

LESSON 15 - PRE-SOLO CROSS-COUNTRY

Objective: During this lesson, the student will be taught to navigate using pilotage, dead reckoning, and radio navigation. He/she will be taught to compute fuel consumption and ETA's to checkpoints and destinations; properly file, comply with, and close VFR flight plans; properly communicate with the appropriate ATC facilities; and respond correctly to enroute emergencies.

Standards: At the conclusion of this lesson, the student must be able to demonstrate his/her ability to conduct safe solo cross-country flights using various means of navigation. He/she must display a thorough knowledge of cross-country flight planning, weather analysis, and use of proper aeronautical publications. He/she should be able to maintain altitude within ± 200 feet and heading within ± 10 degrees while maintaining the proper ground track within 1 mile. In addition, the student must be able to identify his/her position at all times and be able to give a reasonable estimate to another location.

LESSON 16 - SOLO CROSS-COUNTRY

Objective: The student will conduct a three leg, round robin, solo cross-country flight using pilotage, dead reckoning, and radio navigation. This flight should be approximately 1.5 hours duration and should be conducted over the same route as Unit #46 dual cross-country.

Standards: The student must successfully complete a three leg, solo cross-country flight over the route designated by the flight instructor.

LESSON 17 - SOLO CROSS-COUNTRY PHASE CHECK

Objective: To determine by an oral exam and flight check that the student has the necessary knowledge and competence to safely plan and conduct a solo cross-country flight, to include a diversion to an alternate airport and react properly to unanticipated emergencies.

LESSON 17 (Continued)

Standards: The student will be expected to demonstrate his/her ability to safely conduct cross-country operations and should display a thorough knowledge of proper preflight action, flight planning, weather analysis, and aeronautical publications available. He/she should perform all duties of pilot-in-command with smoothness, accuracy, and competence. He/she should be able to divert to an alternate airport and give a reasonable estimate of his/her arrival time and remaining fuel. Prior to arrival at the alternate airport, the student will be placed under the hood until lost. The student should be able to locate his/her position within 3 miles without aid from the instructor by using all means available. The student must also establish and maintain headings required to stay on course, correctly identify his/her position at all times, provide reasonable estimates of estimated arrival times with apparent errors of not more than 10 minutes, maintain altitude ± 200 feet, and establish a course to an alternate, and, within a reasonable time, give an acceptable estimate of the time and fuel required to reach the alternate.

LESSON 18 - SOLO CROSS-COUNTRY

Objective: During this lesson, the student will conduct a three leg, solo cross-country flight with a landing at each airport. Route of the flight and airports of intended landing to be determined by the instructor.

Standards: This lesson will be complete when the student has completed a solo cross-country flight (of approximately 4.0 hours duration) to two airports with stops at each airport. The instructor will conduct a post flight critique to determine that all required flight log entries have been made.

LESSON 19 - SOLO CROSS-COUNTRY

Objective: During this lesson, the student will conduct a three leg, solo cross-country flight to meet FAR Part 61, B-2.

Standards: This lesson is complete when the student has satisfactorily completed a solo cross-country flight (approximately 4.5 hours duration) that has landings at not less than three points, each of which is more than 100 NM from the other points.

PHASE IV - PILOT OPERATIONS - PRIVATE PILOT

OBJECTIVE

The student will receive additional instruction and gain further experience and competence in the preparation for the Private Pilot airplane flight test.

STANDARDS

This phase will be complete when the student successfully passes the Private Pilot Phase Check for this course.

LESSON 20 - CERTIFICATE REVIEW

Objective: During this lesson, the instructor will determine the student's proficiency in all maneuvers and procedures necessary to conduct flight operations as a Private Pilot.

Standards: The student should display the ability to meet the requirements as outlined in the Private Pilot Flight Test Guide, AC 61-54, or its current equivalent, for operations as a Private Pilot.

LESSON 21 - PRIVATE PILOT PHASE CHECK

Objective: To determine by an oral exam and a flight check that the student has the necessary knowledge and skill to conduct flight operations as a Private Pilot.

Standards: The student will demonstrate the required proficiency and knowledge as outlined in the Private Pilot Flight Test Guide, AC 61-54, or its current equivalent.

LESSON 22 - FAA PRIVATE PILOT CHECKRIDE

Objective: To allow the student and instructor to complete the necessary paperwork and certifying procedures so that the student can apply and complete the FAA Private Pilot checkride with either an FAA inspector or an FAA designated examiner.

Standards: The student can make application for the FAA Private Pilot checkride if: he/she has successfully completed the Private Pilot phase check, has successfully passed the FAA Private Pilot written exam, and has completed the following minimum training hours: 20.0 dual hours to include 3.0 dual cross-country hours; 20.0 solo hours to include 10.0 solo cross-country hours; 1.0 hour simulator instruction; 3.0 hours observing; and 3.0 hours in test preparation.

APPENDIX C

PILOT PERFORMANCE DESCRIPTION RECORD (PPDR)

This appendix contains a facsimile of the PPDR, the measure used in the present study to record the performance of the students during the flight checkrides. The rationale underlying the development of the PPDR and the procedures for its use are described in the Methods section. The PPDR in this appendix contains all three task subsets (I, II, and III). Table 1 in the main text identifies the specific task subsets used in each of the four checkrides. Appendix D contains the instructions provided to the checkpilots to guide their use of the PPDR.

The PPDR was produced in the size illustrated in this appendix to facilitate its use in the aircraft during the checkride. Additionally, holes were punched into the PPDR forms to enable them to be inserted into loose leaf binders.

PHASE IV. PRIVATE PILOT PHASE CHECK

Pilot Performance Description Record

1. Embry-Riddle Aeronautical University

STUDENT'S NAME	SSN
TRACK [A] [B]	AIRCRAFT
CHECK PILOT	DATE

2. WEATHER

BEGINNING OF FLIGHT:	END OF FLIGHT:
X WIND [L] [NONE] [R] 15° 30° 45° 60°	X WIND [L] [NONE] [R] 15° 30° 45° 60°
WIND VELOCITY (Knts) 5 10 15 20	WIND VELOCITY (Knts) 5 10 15 20
GUSTS [NONE] [LIGHT] [MOD.]	GUSTS [NONE] [LIGHT] [MOD.]

3. ROUTE IDENTIFICATION: ____________________

CROSS COUNTRY PLANNING

COURSE IS SELECTED, DRAWN, AND MEASURED PROPERLY	YES	NO
WEATHER INFORMATION IS PROPERLY INTERPRETED	YES	NO
FLIGHT LOG IS COMPLETED PROPERLY	YES	NO
FLIGHT PLAN IS COMPLETED PROPERLY	YES	NO
WEIGHT AND BALANCE CALCULATIONS PERFORMED PROPERLY	YES	NO
FLIGHT PLAN IS FILED PROPERLY	YES	NO

COMMENTS:
(Describe any errors in above procedures.)

PREFLIGHT INSPECTION PROCEDURES

PREFLIGHT INSPECTION (INTERIOR AND EXTERIOR) PROCEDURES CORRECT   YES   NO

(If any step is omitted or performed incorrectly, please list it below.)

COMMENTS:

ENGINE START PROCEDURES AND PRETAXI CHECK

ENGINE START PROCEDURES CORRECT YES NO

(If any step is omitted or performed incorrectly, please list it below.)

COMMENTS:

TAXIING TO TAKEOFF POSITION

BRAKE CHECK	YES	NO
PROPER TAXI SPEED	YES	NO
PROPER DIRECTIONAL CONTROL	YES	NO
PROPER APPLICATION OF BRAKES	YES	NO
PROPER EXTERNAL SCAN	YES	NO
PROPER CONTROL POSITIONING	YES	NO
PROPER USE OF POWER	YES	NO

GROUND COMMUNICATION PROCEDURES (TO TAKEOFF)

CORRECT FREQUENCY TUNED	YES	NO
PROPER USE OF MIKE	YES	NO
SPEAKS CLEARLY	YES	NO
MAKES PROPER REQUESTS	YES	NO
UNDERSTANDS MESSAGES	YES	NO
COMPLIES WITH MESSAGES WHILE PERFORMING OTHER TASKS	YES	NO

COMMENTS: (If any procedural step is omitted or performed incorrectly, plea list it below. See "While Taxiing" checklist for these steps.)

ENGINE RUNUP AND BEFORE TAKEOFF CHECK

BEFORE TAKEOFF PROCEDURES CORRECT YES NO

(If any step is omitted or performed incorrectly, please list it below.)

COMMENTS:

TAKEOFF AND DEPARTURE

GROUND RUN

FULL THROTTLE	YES	NO
RUNWAY CENTERLINE TRACK	LEFT	RIGHT

LIFTOFF

AIRSPEED	LOW	-5	55	+5	HIGH
ACCEPTABLE ROTATION		YES		NO	

CLIMBOUT

AIRSPEED	LOW	-5	+5	HIGH
TRACK FROM EXTENDED RUNWAY	LEFT			RIGHT
PROPER PATTERN EXIT		YES	NO	
PROPER TRIM (FOR CLIMB)		YES	NO	

LEVEL OFF

ALTITUDE	LOW	-50	+50	HIGH
TRIM (LEVEL FLIGHT)		YES	NO	

SMOOTH CONTROL	YES	NO
CONTROL COORDINATION	YES	NO (SLIP / SKID)

TURBULENCE	YES	NO

COMMENTS:

VOR TRACKING (CROSS COUNTRY; INBOUND)

IDENTIFICATION

STATION TUNED PROPERLY		YES	NO	
STATION IDENTIFIED		YES	NO	
RADIAL IDENTIFIED		YES	NO	
ALTITUDE (DURING IDENTIFICATION)	-100	-50	+50	+100
HEADING (DURING IDENTIFICATION)	-10°	-5°	+5°	+10°

TRACK TO STATION

TURN TO INBOUND HEADING	-10	-5	+5	+10
ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10°	-5°	+5°	+10°
VOR TRACK ($\pm$ 1 dot)		YES	NO	

TURBULENCE		YES	NO	

COMMENTS:

VOR TRACKING (CROSS COUNTRY, OUTBOUND)

IDENTIFICATION

RADIAL IDENTIFIED		YES	NO	
ALTITUDE (DURING SWITCH)	-100	-50	+50	+100
HEADING (DURING SWITCH)	-10°	-5°	+5°	+10°

TRACK TO STATION

TURN TO OUTBOUND HEADING	-10	-5	+5	+10
ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10°	-5°	+5°	+10°
VOR TRACK (± 1 dot)		YES	NO	
TURBULENCE		YES	NO	

COMMENTS:

FIRST LEG (CROSS COUNTRY)

ESTIMATES PROPER HEADING CORRECTIONS FOR SECOND LEG (DURING FIRST LEG)	YES	NO
CORRECTLY ESTIMATES CORRECTED TIME IN ROUTE FOR SECOND LEG (DURING FIRST LEG)	YES	NO
ESTIMATES FUEL REQUIRED FROM FIRST AIRPORT TO FINAL DESTINATION	YES	NO
LOCATES FIRST AIRPORT	YES	NO
TURNS ON CORRECT HEADING FOR NEXT AIRPORT	YES	NO

COMMENTS:

DIVERSION TO ALTERNATE FIELD

DETERMINES PROPER HEADING CORRECTION FOR ALTERNATE FIELD (USES COMPUTED WIND)	YES	NO
TURNS ON CORRECT HEADING TO ALTERNATE AIRPORT	YES	NO
COMPUTES ETA FOR ALTERNATE AIRPORT	YES	NO
LOCATES ALTERNATE AIRPORT	YES	NO
VERBALIZES COMMUNICATION REQUIREMENTS FOR CHANGE IN FLIGHT PLAN	YES	NO

COMMENTS:

MINIMUM CONTROLLABLE AIRSPEED

ENTRY

PROPER ENTRY PROCEDURES	YES	NO

STRAIGHT AND LEVEL

AIRSPEED	-10	-5	+5	+10
ALTITUDE	-100	-50	+50	+100
HEADING	-10°	-5°	+5°	+10°

TURN

AIRSPEED	-10	-5	+5	+10
ALTITUDE	-100	-50	+50	+100

RECOVERY

PROPER RECOVERY PROCEDURES	YES	NO
PROPER USE OF POWER	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

TAKEOFF AND DEPARTURE STALL

ENTRY

PROPER ENTRY PROCEDURES	YES	NO
AIRSPEED		

RECOVERY

STALL RECOGNIZED	YES	NO
PITCH DECREASED	YES	NO
WINGS LEVEL	YES	NO
ALTITUDE LOSS ACCEPTABLE	YES	NO
AIRSPEED NOT EXCESSIVE	YES	NO

SMOOTH CONTROL	YES	NO

TURBULENCE	YES	NO

COMMENTS:

APPROACH TO LANDING STALL

ENTRY		
PROPER ENTRY PROCEDURES	YES	NO
AIRSPEED	LOW -5 55 +5 HIGH	
BANK	SHALLOW -5° +5° STEEP	
RECOVERY		
STALL RECOGNIZED	YES	NO
FULL THROTTLE	YES	NO
PITCH DECREASED	YES	NO
WINGS LEVEL	YES	NO
CARB HEAT OFF	YES	NO
FLAP RETRACTION	YES	NO
ALTITUDE LOSS ACCEPTABLE	YES	NO
AIRSPEED NOT EXCESSIVE	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

STEEP TURNS (720°)

ENTRY

PROPER ROLLIN			YES		NO	
PROPER USE OF POWER			YES		NO	
			95			
AIRSPEED	-10	-5		+5		+10
ALTITUDE	-100	-50		+50		+100

BANK/TURN

			50°		
ANGLE BANK	-10	-5		+5	+10
			95		
AIRSPEED	-10	-5		+5	+10
ALTITUDE	-100	-50		+50	+100

STEEP TURNS (720°)

RECOVERY

PROPER LEAD		YES	NO	
ALTITUDE	-100	-50	+50	+100
HEADING	-20°	-10°	+10°	-20°
		95		
AIRSPEED	-10	-5	+5	+10
PROPER POWER REDUCTION		YES	NO	

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

ACCELERATED STALL

ENTRY

AREA CLEARED		YES	NO	
MIXTURE RICH		YES	NO	
POWER (RPM)	-100	-50	+50	+100
ALTITUDE	-100	-50	+50	+100

BANK

INITIATE AT 55 KIAS (± 5 KNOTS)		YES	NO	
BANK ANGLE	-10°	-5°	+5°	+10°
ALTITUDE	-100	-50	+50	+100

RECOVERY

STALL RECOGNIZED	YES	NO
PITCH DECREASED PROPERLY	YES	NO
WINGS LEVELLED PROPERLY	YES	NO
FULL POWER	YES	NO
CARB HEAT COLD	YES	NO
PROPER CONTROL COORDINATION	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

ENGINE FAILURE PROCEDURES DURING FLIGHT

	YES	NO
ENGINE FAILURE PROCEDURES CORRECT		
AIRSPEED - 65 KIAS ($\pm$ 2 KNOTS)		
CARB HEAT ON		
FUEL SELECTOR VALVE ON BOTH		
MIXTURE RICH		
IGNITION SWITCH ON BOTH		
PRIMER - IN AND LOCKED		

COMMENTS:

FORCED LANDING

SELECTS FEASIBLE AREA FOR EMERGENCY LANDING	YES	NO
PROPERLY PLANS DIRECTION OF LANDING	YES	NO
PROPER AIRSPEED CONTROL (NOT EXCESSIVELY HIGH OR LOW)	YES	NO
MAINTAINS SCAN FOR HIGH OBSTACLES	YES	NO
WOULD OBTAIN DESIRED TOUCHDOWN POINT	YES	NO
VERBALIZED PROCEDURES FOR EMERGENCY LANDING	YES	NO

COMMENTS:

GO-AROUND PROCEDURES

	YES	NO
GO-AROUND PROCEDURES CORRECT		
THROTTLE - FULL POWER		
PITCH ATTITUDE CHANGED		
CARB HEAT COLD		
FLAPS 20° MAXIMUM		
CLIMB 55 KIAS ($\pm$ 5 KIAS)		
FLAPS RETRACTED PROPERLY		

COMMENTS:

BEFORE LANDING PROCEDURES

BEFORE LANDING PROCEDURES CORRECT	YES	NO
SEATS, BELTS, HARNESSES SECURE		☐
FUEL SELECTOR VALVE ON BOTH		☐
MIXTURE RICH		☐
CARB HEAT ON		☐

COMMENTS:

TRAFFIC PATTERN (UNCONTROLLED FIELD)

ENTRY				
ANGLE (45°)		YES	NO	
ABEAM MIDPOINT		YES	NO	
ALTITUDE	-100	-50	+50	+100
RPM	-100	-50	+50	+100
DISTANCE OUT	TOO CLOSE			TOO FAR
DOWNWIND				
ALTITUDE	-100	-50	+50	+100
COCKPIT CHECK		YES	NO	
REDUCE POWER	EARLY			LATE
AIRSPEED	-10	-5	+5	+10
FLAPS (10°)		YES	NO	
PROPER GROUND TRACK		YES	NO	
TURN STARTED (BASE)	EARLY			LATE

TRAFFIC PATTERN (UNCONTROLLED FIELD)

BASE

AIRSPEED	-10	-5	+5	+10
PROPER GROUND TRACK		YES	NO	
PROPER FLAPS		YES	NO	
TURN STARTED (FINAL)	EARLY			LATE
TRIM		YES	NO	

FINAL

TRACK FROM EXTENDED RUNWAY	LEFT			RIGHT
AIRSPEED	-10	-5	+5	+10
DESCENT RATE	SLOW			FAST
APPROACH ANGLE	SHALLOW			STEEP
PROPER FLAPS		YES	NO	
TRIM		YES	NO	

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

NORMAL LANDING (UNCONTROLLED FIELD)

TRANSITION (FLARE)

				20		
ALTITUDE	-10		-5		+5	+10
PROPER FLARE RATE			YES		NO	
PROPER FLARE ATTITUDE			YES		NO	

TOUCHDOWN

TOUCHDOWN POINT	SHORT			LONG
PROPER POWER		YES	NO	
PROPER NOSE ATTITUDE		YES	NO	
CONTACT	DROP			BOUNCE
RUNWAY CENTERLINE TRACK	LEFT			RIGHT

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

SHORT FIELD TAKEOFF

GROUND RUN	
FULL THROTTLE	YES NO
RUNWAY CENTERLINE TRACK	LEFT RIGHT
LIFTOFF	
AIRSPEED	LOW -5 +5 HIGH
ACCEPTABLE ROTATION	YES NO
CLIMBOUT	
INITIAL AIRSPEED (OVER OBSTACLE)	LOW -5 +5 HIGH
AIRSPEED (AFTER OBSTACLE CLEARED)	LOW -5 +5 HIGH
TRACK FROM EXTENDED RUNWAY	LEFT RIGHT
PROPER TRIM (FOR CLIMB)	YES NO
LEVEL OFF (IN PATTERN)	
ALTITUDE	LOW HIGH
TRIM (LEVEL FLIGHT)	YES NO

SHORT FIELD TAKEOFF

SMOOTH CONTROL	YES	NO
CONTROL COORDINATION	YES	NO
		SLIP SKID
TURBULENCE	YES	NO

COMMENTS:

SHORT FIELD LANDING (BASE AND FINAL)

BASE

AIRSPEED	-10	-5	+5	+10
PROPER GROUND TRACK (EXTENDED)		YES	NO	
PROPER FLAPS		YES	NO	
TURN STARTED (FINAL)	EARLY			LATE
TRIM		YES	NO	

FINAL

TRACK FROM EXTENDED RUNWAY	LEFT			RIGHT
AIRSPEED	-10	-5	+5	+10
DESCENT RATE	SLOW			FAST
APPROACH ANGLE	SHALLOW			STEEP
PROPER FLAPS		YES	NO	
TRIM		YES	NO	

SHORT FIELD LANDING (TRANSITION AND TOUCHDOWN)

TRANSITION (FLARE)

ALTITUDE	-10	-5	20	+5	+10
PROPER FLARE RATE		YES		NO	
PROPER FLARE ATTITUDE		YES		NO	

TOUCHDOWN

TOUCHDOWN POINT	SHORT			LONG
PROPER POWER		YES	NO	
PROPER NOSE ATTITUDE		YES	NO	
CONTACT	DROP			BOUNCE
RUNWAY CENTERLINE TRACK	LEFT			RIGHT
PROPER USE OF BRAKES		YES	NO	

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

SOFT FIELD TAKEOFF

GROUND RUN

PROPER USE OF FLAPS	YES	NO
INITIATED ROLLING START	YES	NO
FULL THROTTLE	YES	NO
RUNWAY CENTERLINE TRACK	LEFT	RIGHT

LIFTOFF

AIRSPEED AT LIFTOFF	LOW -5	+5 HIGH
ACCEPTABLE ROTATION	YES	NO

CLIMBOUT

MAINTAINS PROPER ATTITUDE UNTIL AIRSPEED BUILDS	YES	NO
AIRSPEED (AFTER STARTING CLIMBOUT)	LOW -5	+5 HIGH
TRACK FROM EXTENDED RUNWAY	LEFT	RIGHT
PROPER TRIM (FOR CLIMB)	YES	NO

SOFT FIELD TAKEOFF

LEVEL OFF (IN PATTERN)

ALTITUDE	LOW	HIGH
TRIM (LEVEL FLIGHT)	YES	NO
SMOOTH CONTROL	YES	NO
CONTROL COORDINATION	YES	NO (SLIP / SKID)
TURBULENCE	YES	NO

COMMENTS:

CROSSWIND LANDING (BASE AND FINAL)

BASE

AIRSPEED	-10	-5		+5	+10
PROPER GROUND TRACK		YES		NO	
PROPER FLAPS		YES		NO	
TURN STARTED (FINAL)	EARLY				LATE
TRIM		YES		NO	

INAL

PROPER DRIFT CORRECTION		YES		NO	
TRACK FROM EXTENDED RUNWAY	LEFT				RIGHT
AIRSPEED	-10	-5		+5	+10
DESCENT RATE	SLOW				FAST
APPROACH ANGLE	SHALLOW				STEEP
PROPER FLAPS		YES		NO	
TRIM		YES		NO	

CROSSWIND LANDING (TRANSITION AND TOUCHDOWN)

TRANSITION (FLARE)

			20		
ALTITUDE	-10	-5		+5	+10
PROPER FLARE RATE		YES		NO	
PROPER FLARE ATTITUDE		YES		NO	
PROPER DRIFT CORRECTION		YES		NO	

TOUCHDOWN

TOUCHDOWN POINT	SHORT			LONG
PROPER POWER		YES	NO	
PROPER NOSE ATTITUDE		YES	NO	
PROPER DRIFT CORRECTION		YES	NO	
CONTACT	DROP			BOUNCE
RUNWAY CENTERLINE TRACK	LEFT			RIGHT
PROPER USE OF BRAKES		YES	NO	
SMOOTH CONTROL		YES	NO	
TURBULENCE		YES	NO	

COMMENTS:

CROSSWIND TAKEOFF

GROUND RUN

FULL THROTTLE		YES	NO	
FULL AILERON DEFLECTION		YES	NO	
RUNWAY CENTERLINE TRACK	LEFT			RIGHT

LIFTOFF

AIRSPEED	LOW	-5	+5	HIGH
ACCEPTABLE ROTATION		YES	NO	
PROPER DRIFT CORRECTION		YES	NO	

CLIMBOUT

AIRSPEED	LOW	-5	+5	HIGH
TRACK FROM EXTENDED RUNWAY	LEFT			RIGHT
PROPER TRIM (FOR CLIMB)		YES	NO	

LEVEL OFF

ALTITUDE	LOW			HIGH
TRIM (LEVEL FLIGHT)		YES	NO	

SMOOTH CONTROL	YES	NO	
CONTROL COORDINATION	YES	NO	
		SLIP	SKID

TURBULENCE	YES	NO

COMMENTS:

TURN TO ASSIGNED HEADING

BANK ANGLE	-10°	-5°	30°	+5°	+10°
ALTITUDE	-100	-50		+50	+100
AIRSPEED	-10	-5		+5	+10
ROLLOUT ON ASSIGNED HEADING	-10°	-5°		+5°	+10°

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

STRAIGHT AND LEVEL FLIGHT

	-10	-5	105	+5	+10
AIRSPEED					
	-10°	-5°		+5°	+10°
HEADING					
	-100	-50		+50	+100
ALTITUDE					
PROPER TRIM		YES		NO	
SMOOTH CONTROL		YES		NO	
TURBULENCE		YES		NO	

COMMENTS:

"S" TURNS ACROSS A ROAD

ENTERS DOWNWIND		YES	NO	
1st TURN				
ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10
CORRECT BANK ANGLES FOR DRIFT CORRECTION		YES	NO	
WINGS LEVEL AT ROAD		YES	NO	
2nd TURN				
ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10
CORRECT BANK ANGLES FOR DRIFT CORRECTION		YES	NO	
SMOOTH CONTROL		YES	NO	
COORDINATED TURNS		YES	NO	
TURBULENCE		YES	NO	

COMMENTS:

TURNS ABOUT A POINT

ENTER DOWNWIND	YES	NO

st TURN

ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10

2nd TURN

ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10

CONSTANT RADIUS TURN	YES	NO

PROPER EXIT HEADING	-10°	-5°	+5°	+10°

MAINTAIN AIRSPACE SCAN	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

RATE CLIMB (HOOD)

INITIATE

POWER INCREASE (RPM)	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10
HEADING	-10°	-5°	+5°	+10°

MAINTAIN

VERTICAL SPEED (FPM)	-100	-50	+50	+100
HEADING	-10°	-5°	+5°	+10°

.EVELOFF

HEADING	-10°	-5°	+5°	+10°
ASSIGNED ALTITUDE	-100	-50	+50	+100

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

MAGNETIC COMPASS TURN (W-S; 270°) (HOOD)

SETUP

PROPER SETUP	YES	NO

ROLLIN

BANK	-10°	-5°	+5°	+10°
ALTITUDE	-100	-50	+50	+100

MAINTAIN

BANK	-10°	-5°	+5°	+10°
ALTITUDE	-100	-50	+50	+100

ROLLOUT

ALTITUDE	-100	-50		+50	+100
DEGREES TURNED	-10°	-5°	270	+5°	+10°

PROPER LEAD/LAG	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

UNUSUAL ATTITUDE RECOVERIES (HOOD)

RECOGNITION		
RECOGNITION OF ATTITUDE	YES	NO
RECOVERY		
CORRECT AND TIMELY CONTROL MOVEMENTS	YES	NO
INITIAL ALTITUDE RECOVERED (± 100ft.)	YES	NO
HEADING CONTROL (RECOVERY)	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

180° TURNS (HOOD)

PROPER ROLLIN		YES		NO
BANK ANGLE	-10°	-5°	+5°	+10°
ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10
ROLLOUT ON ASSIGNED HEADING	-10°	-5°	+5°	+10°
SMOOTH CONTROL		YES		NO
TURBULENCE		YES		YES

COMMENTS:

AIRSPEED CHANGE (HOOD)

DECELERATION (CRUISE TO 70 KIAS)

PROPER POWER DECREASE		YES	NO	
HEADING	-20	-10	+10	+20
ALTITUDE	-100	-50	+50	+100
ASSIGNED AIRSPEED (± 3 KIAS)		YES	NO	

ACCELERATION (70 KIAS TO CRUISE)

PROPER SETUP		YES	NO	
PROPER POWER INCREASE		YES	NO	
HEADING	-20	-10	+10	+20
ALTITUDE	-100	-50	+50	+100
ASSIGNED AIRSPEED (± 3 KIAS)		YES	NO	
SMOOTH CONTROL		YES	NO	
TURBULENCE		YES	NO	

COMMENTS:

VOR TRACKING (HOOD)

IDENTIFICATION

STATION TUNED PROPERLY		YES	NO	
STATION IDENTIFIED		YES	NO	
RADIAL IDENTIFIED		YES	NO	
ALTITUDE	-100	-50	+50	+100
HEADING	-10°	-5°	+5°	+10°

RACK TO STATION

TURN TO INBOUND HEADING	-10	-5	+5	+10
ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10
VOR TRACK (± 1 dot)		YES	NO	

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

TYPE OF ENTRY (CHECK)

☐ DOWNWIND

☐ BASE

☐ FINAL

TRAFFIC PATTERN (CONTROLLED FIELD)

ENTRY

ANGLE (45°)		YES	NO	
ABEAM MIDPOINT		YES	NO	
ALTITUDE	-100	-50	+50	+100
RPM	-100	-50	+50	+100
DISTANCE OUT	TOO CLOSE			TOO FAR

DOWNWIND

ALTITUDE	-100	-50	+50	+100
COCKPIT CHECK		YES	NO	
REDUCE POWER	EARLY			LATE
AIRSPEED	-10	-5	+5	+10
FLAPS (10°)		YES	NO	
PROPER GROUND TRACK		YES	NO	
TURN STARTED (BASE)	EARLY			LATE

TRAFFIC PATTERN (CONTROLLED FIELD)

BASE

AIRSPEED	-10	-5		+5	+10
PROPER GROUND TRACK		YES		NO	
PROPER FLAPS		YES		NO	
TURN STARTED (FINAL)	EARLY				LATE
TRIM		YES		NO	

FINAL

TRACK FROM EXTENDED RUNWAY	LEFT				RIGHT
AIRSPEED	-10	-5		+5	+10
DESCENT	SLOW				FAST
APPROACH ANGLE	SHALLOW				STEEP
PROPER FLAPS		YES		NO	
TRIM		YES		NO	

COMMENTS:

LANDING (CONTROLLED FIELD)

TRANSITION (FLARE)		
ALTITUDE	-10 -5 20 +5 +10	
PROPER FLARE RATE	YES	NO
PROPER FLARE ATTITUDE	YES	NO
TOUCHDOWN		
TOUCHDOWN POINT	SHORT	LONG
PROPER POWER	YES	NO
PROPER NOSE ATTITUDE	YES	NO
CONTACT	DROP	BOUNCE
RUNWAY CENTERLINE TRACK	LEFT	RIGHT
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

TAXIING TO RAMP

BRAKES CHECKED	YES	NO
PROPER TAXI SPEED	YES	NO
PROPER DIRECTIONAL CONTROL	YES	NO
PROPER APPLICATION OF BRAKES	YES	NO
PROPER POWER APPLICATION	YES	NO
PROPER EXTERNAL SCAN	YES	NO
PROPER CONTROL POSITIONING	YES	NO

GROUND COMMUNICATION PROCEDURES (AFTER LANDING)

CORRECT FREQUENCY TUNED	YES	NO
PROPER USE OF MIKE	YES	NO
SPEAKS CLEARLY	YES	NO
MAKES PROPER REQUESTS	YES	NO
UNDERSTANDS MESSAGES	YES	NO
COMPLIES WITH MESSAGES WHILE PERFORMING OTHER TASKS	YES	NO

COMMENTS:

SECURING AIRPLANE PROCEDURES

	YES	NO
SECURING AIRPLANE PROCEDURES CORRECT		
PARKING BRAKE SET		
AVIONICS POWER SWITCH/ELECTRICAL EQUIPMENT OFF		
MIXTURE - IDLE CUT-OFF		
IGNITION SWITCH - OFF		
MASTER SWITCH - OFF		
CONTROL LOCK INSTALLED		

COMMENTS:

ALL AIRBORNE COMMUNICATION PROCEDURES

ALL FREQUENCIES TUNED CORRECTLY AND PROMPTLY	YES	NO
PROPER USE OF MIKE	YES	NO
SPEAKS CLEARLY	YES	NO
MAKES PROPER REQUESTS	YES	NO
UNDERSTANDS ALL MESSAGES	YES	NO
COMPLIES WITH ALL MESSAGES WHILE PERFORMING OTHER TASKS	YES	NO

COMMENTS:

APPENDIX D

STUDENT OPINION SURVEY

This appendix contains a copy of the Student Opinion Survey that was given to the students after they had completed the fourth checkride. Procedures for administration of the survey are described in the Methods section of the main text.

To be completed after
the fourth checkride

STUDENT OPINION SURVEY

NAME: ______________________ Soc. Sec. Number: ________________

The purpose of this survey is to obtain your opinion of the Pilot Evaluation Program. Your answers to these questions will be used to aid in the determination of the effects of the distribution of flying and training time on private pilot instruction. Additionally, your opinion is sought concerning the influence of participation in the Program, regardless of the experimental group in which you were put, on the performance of your job with the FAA.

Your answers will remain anonymous. That is, answers given by specific individuals will not be discussed with their instructors or with FAA personnel. Your name is needed, however, to enable the information obtained from this survey to be analyzed with respect to the other data collected during this study--e.g., the flight check data.

Most of the following questions have multiple choice answers. Circle the number of the alternative that you select.

1. In general, how difficult was the training you received?

   1. Very easy
   2. Easy
   3. Moderately easy
   4. Moderately hard
   5. Hard
   6. Very hard

2. How pleasant did you find private pilot training in general?

   1. Very unpleasant
   2. Unpleasant
   3. Moderately unpleasant
   4. Moderately pleasant
   5. Pleasant
   6. Very pleasant

3. How much effort did you usually devote to preparing for training flights?

   1. None at all
   2. Very little
   3. A little
   4. A moderate amount
   5. A substantial amount
   6. An extreme amount

4. In general, how much more time would you like to have had to prepare for your training flights?

   1. None at all
   2. Very little more
   3. A little more
   4. A moderate amount more
   5. A substantial amount more
   6. An extreme amount more

5. (a) How pleasant did you find flying to be during your first three solos?

   1. Very unpleasant
   2. Unpleasant
   3. Moderately unpleasant
   4. Moderately pleasant
   5. Pleasant
   6. Very pleasant

   (b) How pleasant do you find flying solo to be now?

   1. Very unpleasant
   2. Unpleasant
   3. Moderately unpleasant
   4. Moderately pleasant
   5. Pleasant
   6. Very pleasant

6. How frequently did you become nervous or anxious while flying solo during your training?

   1. Not at all
   2. Very little
   3. A little
   4. A moderate amount
   5. A substantial amount
   6. An extreme amount

7. (a) In general, how much has your participation in the Pilot Evaluation Program aided you in the performance of your job at the Technical Center?

   1. Not at all
   2. Very little
   3. A little
   4. A moderate amount
   5. A substantial amount
   6. An extreme amount

   (b) If you feel your participation in this program has aided you in the performance of your job, please describe some examples of how this experience has been of use.

8. How much do you feel your immediate supervisor believes your participation in this Pilot Evaluation Program has aided you in the performance of your job at the Technical Center?

   1. Not at all
   2. Very little
   3. A little
   4. A moderate amount
   5. A substantial amount
   6. An extreme amount

9. In general, how much do you feel your participation in the Pilot Evaluation Program distracted you from your job at the Technical Center?

   1. Not at all
   2. Very little
   3. A little
   4. A moderate amount
   5. A substantial amount
   6. An extreme amount

10. How much do you feel your immediate supervisor believes you were distracted from your job at the Technical Center by your participation in the program?

1. Not at all
2. Very little
3. A little
4. A moderate amount
5. A substantial amount
6. An extreme amount

11. How much do you feel flight and ground school training distracted you from activities connected with your home life and other leisure time pursuits?

1. Not at all
2. Very little
3. A little
4. A moderate amount
5. A substantial amount
6. An extreme amount

12. (a) How much <u>more</u> frequently would you like to have flown during your training (i.e., maintaining the same total number of flight hours, but flying more frequently each week)?

1. I would <u>not</u> like to have flown <u>more</u> frequently
2. Very little more
3. A little more
4. A moderate amount more
5. A substantial amount more
6. An extreme amount more

(b) If you would have liked to have flown <u>more</u> frequently, please state why.

13. (a) How much <u>less</u> frequently would you like to have flown during your training (i.e., maintaining the same total number of flight hours, but less frequently each week)?

1. I would <u>not</u> like to have flown <u>less</u> frequently
2. Very little less
3. A little less
4. A moderate amount less
5. A substantial amount less
6. An extreme amount less

(b) If you would have liked to have flown less frequently, please state why.

14. How much trouble, if any, did you have remembering what you had learned on previous flights during later flights?

1. None at all
2. Very little
3. A little
4. A moderate amount
5. A substantial amount
6. An extreme amount

15. (a) How much do you plan on flying after you receive your private pilot's license?

1. None
2. An average of 1-4 hours a month
3. An average of 5-10 hours a month
4. An average of 10-20 hours a month
5. An average of 20-40 hours a month
6. An average of more than 40 hours a month

(b) If you marked alternative 1, please circle all of the reasons why you will not fly.

1. I don't like flying
2. I don't like flying as much as other activities in which I can engage
3. High costs
4. Lack of time
5. No reasons to fly
6. Spouse does not want me to fly
7. Other (please describe):

(c) If you do plan to fly, but feel you will probably not fly as much as you will want, please circle all of the reasons why you will probably not fly as much as you want.

1. High costs
2. Lack of time
3. Would rather do other activities
4. No way to justify flying more often
5. Spouse does not want me to fly
6. Weather
7. Other (please describe):

17. (a) How much overall benefit do you feel the Pilot Evaluation Program (across all students) will be to the FAA?

1. None at all
2. Very little
3. A little
4. A moderate amount
5. A substantial amount
6. An extreme amount

(b) State the reasons for your answer.

18. (a) Circle the number along the line between each pair of words to indicate your feelings toward the training you received in the aircraft.

Hard	1	2	3	4	5	6	Easy
Effective	1	2	3	4	5	6	Ineffective
Efficient	1	2	3	4	5	6	Inefficient
Interesting	1	2	3	4	5	6	Uninteresting
Job relevant	1	2	3	4	5	6	Not job relevant
Inspiring	1	2	3	4	5	6	Uninspiring
Thorough	1	2	3	4	5	6	Incomplete
Organized	1	2	3	4	5	6	Unorganized
Friendly	1	2	3	4	5	6	Unfriendly
Harried	1	2	3	4	5	6	Leisurely
Pleasant	1	2	3	4	5	6	Unpleasant

(b) Circle the number along the line between each pair of words to indicate your feelings toward the ground training you received.

Hard	1	2	3	4	5	6	Easy
Effective	1	2	3	4	5	6	Ineffective
Efficient	1	2	3	4	5	6	Inefficient
Interesting	1	2	3	4	5	6	Uninteresting
Job relevant	1	2	3	4	5	6	Not job relevant
Inspiring	1	2	3	4	5	6	Uninspiring
Thorough	1	2	3	4	5	6	Incomplete
Organized	1	2	3	4	5	6	Unorganized
Friendly	1	2	3	4	5	6	Unfriendly
Harried	1	2	3	4	5	6	Leisurely
Formal	1	2	3	4	5	6	Informal
Pleasant	1	2	3	4	5	6	Unpleasant

19. Please rate the difficulty you experienced in learning to perform the following tasks correctly. Use the following 6-point scale.

1. I experienced no difficulty.
2. I experienced very little difficulty.
3. I experienced a little difficulty.
4. I experienced a moderate amount of difficulty.
5. I experienced a substantial amount of difficulty.
6. I experienced an extreme amount of difficulty.

Circle the number that best indicates how much difficulty you had in learning to perform each of these tasks.

TASKS	NONE	VERY LITTLE	A LITTLE	A MODERATE AMOUNT	A SUBSTANTIAL AMOUNT	AN EXTREME AMOUNT
a. Planning a cross-country trip	1	2	3	4	5	6
b. Conducting an engine run-up and before takeoff check	1	2	3	4	5	6
c. Taking off and departing from ACY	1	2	3	4	5	6
d. Tracking a VOR signal	1	2	3	4	5	6
e. Flying straight and level	1	2	3	4	5	6
f. Flying at minimum controllable airspeed	1	2	3	4	5	6
g. Performing takeoff and departure stalls	1	2	3	4	5	6
h. Performing approach to landing stalls	1	2	3	4	5	6
i. Performing steep turns (720°)	1	2	3	4	5	6
j. Performing accelerated stalls	1	2	3	4	5	6
k. Performing engine failure during flight procedures	1	2	3	4	5	6
l. Performing forced landing procedures	1	2	3	4	5	6

TASKS	NONE	VERY LITTLE	A LITTLE	A MODERATE AMOUNT	A SUBSTAN-TIAL AMOUNT	AN EXTREME AMOUNT
m. Performing go-around procedures	1	2	3	4	5	6
n. Flying a traffic pattern at an uncontrolled field	1	2	3	4	5	6
o. Making a normal landing at an uncontrolled field	1	2	3	4	5	6
p. Making short-field takeoffs (uncontrolled field)	1	2	3	4	5	6
q. Making short-field landings (uncontrolled field)	1	2	3	4	5	6
r. Making soft field takeoffs (uncontrolled field)	1	2	3	4	5	6
s. Making crosswind landings (uncontrolled field)	1	2	3	4	5	6
t. Making crosswind takeoffs (uncontrolled field)	1	2	3	4	5	6
u. Making S turns across a road	1	2	3	4	5	6
v. Making turns about a point	1	2	3	4	5	6
w. Performing a rate climb under the hood	1	2	3	4	5	6
x. Performing a magnetic compass turn under the hood	1	2	3	4	5	6
y. Performing unusual attitude recoveries under the hood	1	2	3	4	5	6
z. Performing 180° turns under the hood	1	2	3	4	5	6
aa. Flying a traffic pattern at a controlled field (ACY)	1	2	3	4	5	6
bb. Making a normal landing at ACY	1	2	3	4	5	6
cc. Performing all radio communication tasks	1	2	3	4	5	6

APPENDIX E

PRE- AND POST-CHECK QUESTIONNAIRES

This appendix contains copies of (1) the pre-check questionnaire, which asked students to predict how they would perform on the fourth checkride; and (2) the post-check questionnaire, which asked them to evaluate their performance after they had completed the checkride. The rationale underlying development of these questionnaires is described in Section I. Section II describes administration procedures.

PHASE CHECK: III IV
(circle one)

STUDENT PRE-CHECK QUESTIONNAIRE

Name: ____________________ Soc. Sec. Number: ____________________

This questionnaire is part of the overall experiment of which your training is a part. Objective data concerning your flight skills are being gathered through the use of the phase checks with which you are already familiar. The purpose of this questionnaire is to obtain your own subjective assessment of your skills. This assessment will be compared with the objective measures obtained during the phase checks and with subjective ratings you will make after your checkride on a Post-Check Questionnaire.

The data obtained from these questionnaires will aid in the determination of the abilities of private pilots to assess their own skills. Such a determination is of great importance since general aviation pilots, once they have received their certificates, must be able to (1) judge if they can perform certain flight tasks safely, (2) assess the adequacy with which they accomplish tasks they do perform, and (3) determine when they need refresher or additional training to improve their skills. Increased understanding of the ability of general aviation pilots to make these judgments will aid in determining how to prevent accidents from happening in which pilots attempt maneuvers that are beyond their skill levels.

None of the instructors, including the one who is administering your checkride, will see your answers to this or the Post-Check Questionnaire. Please be frank and provide honest estimates of your ability to perform these tasks.

Please rate your ability to perform the following tasks, using the 7-point scale provided next to each task. Descriptive statements for scale points 1, 3, 5, and 7 are as follows:

1. I will probably be able to perform the task with NO ERRORS.

3. I will probably make a FEW ERRORS, but I will perform the task well enough to pass it easily on my checkride.

5. I will probably make SEVERAL ERRORS and barely pass the task on my checkride.

7. I will probably make MANY ERRORS and be unable to perform the task satisfactorily on my checkride.

Circle the number that best indicates how well you will perform each task on the checkride you are about to take.

	TASKS	NO ERRORS		FEW ERRORS		SEVERAL ERRORS		MANY ERRORS
1.	Planning a cross-country trip	1	2	3	4	5	6	7
2.	Conducting an engine run-up and before takeoff check	1	2	3	4	5	6	7
3.	Taking off and departing from ACY	1	2	3	4	5	6	7
4.	Tracking a VOR signal	1	2	3	4	5	6	7
5.	Flying straight and level	1	2	3	4	5	6	7
6.	Flying at minimum controllable airspeed	1	2	3	4	5	6	7
7.	Performing takeoff and departure stalls	1	2	3	4	5	6	7
8.	Performing approach to landing stalls	1	2	3	4	5	6	7
9.	Performing steep turns (720°)	1	2	3	4	5	6	7
10.	Performing accelerated stalls	1	2	3	4	5	6	7
11.	Performing engine failure during flight procedures	1	2	3	4	5	6	7
12.	Performing forced landing procedures	1	2	3	4	5	6	7
13.	Performing go-around procedures	1	2	3	4	5	6	7
14.	Flying a traffic pattern at an uncontrolled field	1	2	3	4	5	6	7
15.	Making a normal landing at an uncontrolled field	1	2	3	4	5	6	7
16.	Making short-field takeoffs (uncontrolled field)	1	2	3	4	5	6	7
17.	Making short-field landings (uncontrolled field)	1	2	3	4	5	6	7

	TASKS	NO ERRORS		FEW ERRORS		SEVERAL ERRORS		MANY ERRORS
18.	Making soft field takeoffs (uncontrolled field)	1	2	3	4	5	6	7
19.	Making crosswind landings (uncontrolled field)	1	2	3	4	5	6	7
20.	Making crosswind takeoffs (uncontrolled field)	1	2	3	4	5	6	7
21.	Making S turns across a road	1	2	3	4	5	6	7
22.	Making turns about a point	1	2	3	4	5	6	7
23.	Performing a rate climb under the hood	1	2	3	4	5	6	7
24.	Performing a magnetic compass turn under the hood	1	2	3	4	5	6	7
25.	Performing unusual attitude recoveries under the hood	1	2	3	4	5	6	7
26.	Performing 180° turns under the hood	1	2	3	4	5	6	7
27.	Flying a traffic pattern at a controlled field (ACY)	1	2	3	4	5	6	7
28.	Making a normal landing at ACY	1	2	3	4	5	6	7
29.	Performing all radio communication tasks tasks	1	2	3	4	5	6	7

PHASE CHECK: III IV
(circle one)

STUDENT POST-CHECK QUESTIONNAIRE

Name: ______________________ Soc. Sec. Number: ______________________

Now that you have taken your checkride, please rate your performance on that flight on the following tasks, using the 7-point scale beside each task. Descriptive statements for scale points 1, 3, 5, and 7 are as follows:

1. I performed the task with NO ERRORS.

3. I made a FEW ERRORS, but probably performed the task well enough to pass it easily.

5. I made SEVERAL ERRORS and probably barely passed the task.

7. I made MANY ERRORS and probably did not perform the task satisfactorily.

Circle the number that best indicates how well you performed each of the following tasks.

	TASKS	NO ERRORS		FEW ERRORS		SEVERAL ERRORS		MANY ERRORS
1.	Planning a cross-country trip	1	2	3	4	5	6	7
2.	Conducting an engine run-up and before takeoff check	1	2	3	4	5	6	7
3.	Taking off and departing from ACY	1	2	3	4	5	6	7
4.	Tracking a VOR signal	1	2	3	4	5	6	7
5.	Flying straight and level	1	2	3	4	5	6	7
6.	Flying at minimum controllable airspeed	1	2	3	4	5	6	7
7.	Performing takeoff and departure stalls	1	2	3	4	5	6	7
8.	Performing approach to landing stalls	1	2	3	4	5	6	7
9.	Performing steep turns (720°)	1	2	3	4	5	6	7
10.	Performing accelerated stalls	1	2	3	4	5	6	7

	TASKS	NO ERRORS		FEW ERRORS		SEVERAL ERRORS		MANY ERRORS
11.	Performing engine failure during flight procedures	1	2	3	4	5	6	7
12.	Performing forced landing procedures	1	2	3	4	5	6	7
13.	Performing go-around procedures	1	2	3	4	5	6	7
14.	Flying a traffic pattern at an uncontrolled field	1	2	3	4	5	6	7
15.	Making a normal landing at an uncontrolled field	1	2	3	4	5	6	7
16.	Making short-field takeoffs (uncontrolled field)	1	2	3	4	5	6	7
17.	Making short-field landings (uncontrolled field)	1	2	3	4	5	6	7
18.	Making soft field takeoffs (uncontrolled field)	1	2	3	4	5	6	7
19.	Making crosswind landings (uncontrolled field)	1	2	3	4	5	6	7
20.	Making crosswind takeoffs (uncontrolled field)	1	2	3	4	5	6	7
21.	Making S turns across a road	1	2	3	4	5	6	7
22.	Making turns about a point	1	2	3	4	5	6	7
23.	Performing a rate climb under the hood	1	2	3	4	5	6	7
24.	Performing a magnetic compass turn under the hood	1	2	3	4	5	6	7
25.	Performing unusual attitude recoveries under the hood	1	2	3	4	5	6	7
26.	Performing 180° turns under hood	1	2	3	4	5	6	7
27.	Flying a traffic pattern at a controlled field (ACY)	1	2	3	4	5	6	7
28.	Making a normal landing at ACY	1	2	3	4	5	6	7
29.	Performing all radio communication tasks	1	2	3	4	5	6	7

APPENDIX F

INSTRUCTIONS GIVEN TO THE CHECKPILOTS TO GUIDE THEIR USE OF THE PPDR

This appendix contains the handbook that was used as a reference for training the checkpilots to use the PPDR. The PPDR and the way it was used in the study are described in the Methods section. Appendix C contains a facsimile of the PPDR. Training of the checkpilots is described under Procedure in the main text.

Handbook

Pilot Performance Description Record (PPDR)

I. Purpose

A. General - to provide a method of clearly describing and documenting student pilot performance.

B. Specific - to provide objective performance data for evaluating Contact performance of students in various training tracks.

II. Guiding Principles

A. To obtain a maximum of descriptive and specific judgmental information with a minimum of inflight marking.

B. To be made compatible with existing FAA and E-RAU checkride procedures.

C. To provide a snapshot sample of student performance of those flying skills required for Private Pilot Certification.

III. PPDR Characteristics and General Utilization

A. Each flight maneuver in this PPDR has been analyzed and discussed with E-RAU personnel to determine its fundamental components. The analyses provided the basis for the development of descriptive and judgmental scales on which each performance component, such as direction, attitude, power, and flight path, could be quickly described by the checkpilot.

B. This PPDR includes a sample of the procedures and maneuvers described in the FAA flight test guide on which proficiency must be demonstrated to pass the checkride for Private Pilot certification. This PPDR is intended to provide descriptive data for this sample only, and, as such, it should be viewed as a part of the checkride and not as a substitute for the more comprehensive set of checkride maneuvers prescribed by the checkpilot. Administration of this PPDR should not restrict or constrain the checkpilot's usual checkride prerogatives. In particular, inflight safety must not be jeopardized. The sequence of PPDR maneuvers should be standardized as described in E. below. The performance description resulting from this PPDR is considered to be as complete as can be obtained efficiently by manual recording during flight periods.

C. In any data collection effort, reliability (meaning consistency or repeatability of test result) and validity (meaning measurement of that which is intended to be measured) are desirable goals. One

necessary factor in achieving high levels of reliability and validity is standardization of the test sample, test conditions, and methods of data recording. The standardization of the flight test sample and the methods for administering and evaluating it is the aim of the PPDR.

D. This PPDR is separated into four sections, one for each phase of the private pilot certification course. The four phases are Phase 1, Presolo; Phase 2, Basic Pilot Operations; Phase 3, Cross-Country Flight Operations; and Phase 4, Private Pilot Operations. Each section or phase check consists of a series of functional context procedures/maneuvers in a recommended standardized sequence for recording. Each maneuver is divided into segments that specify observations that are to be made as objectively as possible. During a flight check, student performance normally is recorded during or near the end of each maneuver segment, provided that performance is within the limits specified as "proper" on all scales in that segment. Whenever an error exceeding "proper limits" of a scale occurs, the checkpilot should record it immediately, regardless of how much of the segment is completed. If, later in the segment, the student exceeds his previous error on the same scale, the checkpilot makes a second mark farther out on the scale. Generally speaking, erratic performance is reflected by multiple marking; for example, if the descent rate during an approach is uneven, both "slow" and "fast" may be marked.

E. There are three general levels of detail represented in the PPDR: (1) individual performance measures, (2) flight segments, and (3) maneuvers. Segments and measures are listed in the approximate sequence in which they occur during execution of the maneuver. This is intended to simplify and standardize inflight data recording.

Individual Performance Measures. The PPDR measuring scales show the detailed and descriptive criteria of student performance which underlie the evaluation made by the checkpilot. Examples of these scales are RPM, airspeed, altitude, and ground track. These scales are recorded objectively by the checkpilot from instruments or clearly definable outside references. However, it is not always possible to find such outside references for certain crucial aspects of student performance. Consequently, a few scales are judgmental in nature, e.g., pattern exit or control smoothness. The checkpilot must use his judgment in evaluating and recording these items.

Additionally, to assist the checkpilot in confirming or validating a particular procedure, the students must touch or move the appropriate item and verbalize the procedures--e.g., during preflight inspection, engine start, before takeoff procedures. Verbalization of procedures also serves to reinforce student learning.

Flight Segments. The subdivision of each PPDR flight maneuver into its segments is indicated by single horizontal lines between segments. The segment breaks serve to remind the checkpilot of the

time required for that particular group of measures. More importantly, they make it easier for the checkpilot to focus on a particular group of measures for the specific portion of flight performance being recorded. This reduces the difficulty in determining the flight performance sample to which each measure applies. Occasionally, a measure refers only to a specific part (beginning or end) of a segment; but these instances will be obvious to the checkpilot. Segments and measures are sequenced from the top of the page to the bottom.

Maneuvers. There are several factors about the selected flight maneuvers that the PPDR seeks to control. One factor is the specification of performance measures and segments within maneuvers. The PPDR also requires that all students perform identical maneuvers, which ensures that the same behavioral patterns are sampled in all students. Because the sequence in which maneuvers are given during a flight check can affect the results, the sequence for the PPDR maneuvers has been standardized. The sequence which has been settled upon should allow for maximum use of available time and resources. Due to the requirement for economy of time and effort in conducting the checkride, the performance sequence of maneuvers may be varied to expedite or to increase its efficiency or convenience. However, this standardized sequence should be followed as closely as possible. All maneuvers must be completed for each checkride. The recommended sequence for the Phase I (Presolo) check is:

1. Preflight inspection procedures
2. Engine start
3. Taxiing to takeoff position
4. Before takeoff procedures
5. Takeoff and departure
6. Turn to assigned heading
7. Straight and level
8. Slow flight
9. Takeoff and departure stall
10. Approach to landing stall
11. Engine failure during flight
12. Before landing procedure
13. Traffic pattern (uncontrolled field)
14. Landing (uncontrolled field)
15. Traffic pattern (controlled field)
16. Landing (controlled field)
17. Taxiing to ramp
18. Securing airplane procedures

F. PPDR reliability is dependent upon the degree of standardization achieved in administering checkrides. It is essential that every checkpilot thoroughly understand each measure in this PPDR as described in this appendix. In addition to knowing the measure definitions, it is important that the checkpilot clearly understand that he has two roles, evaluator and recorder. In his normal role as evaluator, the checkpilot observes student performance throughout the

entire checkride, and renders his assessment of that performance based on the proficiency that he observes. As a recorder, he is asked to provide accurate and descriptive information on the observed performance as it occurs and upon which his evaluation is ultimately based. The recording function is thus extremely critical to the PPDR data collection effort. To achieve the goal of accuracy and completeness of recording, the student's performance should be recorded as soon after it occurs as is practical, with due consideration for safety.

G. The checkpilot should maintain an impartial attitude toward the student, limiting conversation to explaining checkride requirements and conditions.

H. The student pilot should not be given detailed feedback relative to checkride performance prior to debriefing.

I. Measures included in this PPDR are of two types:

1. Performance Scales with a desired range of values indicated by a triangular symbol at the scale midpoint, and errors (e.g., left/right), to either side of the triangle. For some measures a desired value is specified at the top of the triangle. Other measures include a '0' above the triangle, indicating that the checkpilot must determine the correct desired value depending upon the aircraft, airspace, or prevailing conditions.

2. Categorical Measures (yes or no) requiring the checkpilot to determine whether or not the observed performance is within acceptable limits. This determination involves more complex judgment for some measures (e.g., constant turn radius) than others (e.g., full throttle).

J. For the scale measures that include a specified deviation range (i.e., tolerance) around the midpoint, the tolerance band specified may or may not be identical to the standards given in the FAA flight test guide. These bands are not necessarily intended to denote FAA acceptable performance, but rather to generate accurate data to document observable performance differences.

K. This version of the PPDR is not intended for use in diagnosing student performance deficiencies. However, research has shown that use of the PPDR can lead to such diagnosis by providing instructors and training managers with a valid and reliable performance data base describing typical and atypical student performance. These data may then be used as an index of comparison (norm) for any given student's observed performance, and therefore provide effective performance feedback to that student.

IV. PPDR Data Recording

A. The cover page of the PPDR is divided into two parts. Part One contains descriptive information about the student, checkpilot, aircraft, etc. and should be completed in its entirety prior to the checkride. Part Two contains weather data. The direction and velocity of crosswind as well as existing turbulence should be recorded both before <u>and</u> after the checkride.

B. Each scale should be marked with at least one slash mark of approximately 1/4 inch in length. The mark should pass clearly and evenly through the scale such that there is no doubt about which scale or which portion of the scale the checkpilot intended to mark. Categorical measures should include a slash mark in the appropriate box.

C. For those segments encompassing an extended period of time (e.g., climbout and pattern exit after takeoff), multiple marks will likely be necessary. This gives a record of deviations as they are observed without forcing the checkpilot to rely upon his memory of an extended performance segment. Errors observed in both directions (e.g., low <u>and</u> high) should be appropriately recorded. Short term segments (e.g., flare) should include only one mark for each measure. Requirement for multiple marking should be apparent to checkpilots.

D. If dangerous performance occurs, the checkpilot should write a letter "D" in the left margin and draw a line to the scale(s) reflecting the dangerous performance. If a maneuver is aborted because of student-induced dangerous performance, an additional notation should be made in the margin and all remaining measures on that maneuver marked in error.

E. If the checkpilot finds it necessary to assist the student with a maneuver, "CP Assist" should be noted in the margin for the affected portion of the maneuver or segment.

F. Go-arounds and their reason should be noted in the margin. When a go-around is initiated for any reason, the checkpilot shall note the go-around point on the PPDR, allow one additional approach, and begin marking at the point of go-around. If erratic student performance necessitates a second go-around, all remaining PPDR measures shall be marked in error, and PPDR recording shall terminate. If the go-arounds are, in the judgment of the checkpilot, weather or traffic-induced, a notation to that effect should be made in the margin, and remaining measures left unmarked.

G. The checkpilot should write any additional comments that he deems pertinent to the recorded performance data in the spaces provided at the bottom of each maneuver form. He may also write to the side of or directly above measures or segments, time and space permitting.

APPENDIX G

STATISTICAL ANALYSIS PROCEDURES

In presenting data in this report, several types of statistics are used. To summarize the general nature or typical value for a group of measures, descriptive statistics such as the Arithmetic Mean (M) and Standard Deviation (SD) are used. The M is that statistic which is commonly referred to as "the average," while the SD is an indicator of the degree of variability among individual measures about the group M value.

In evaluating whether two or more sets of data (e.g., Groups A, B, and C) differ to a degree greater than might be expected by chance, various statistical significance tests are used. In the present report, these are the "t-test," "chi-squared" test, and the "analysis of variance (ANOVA)."

Degree of departure from chance expectation is expressed in terms of probability statements. For example, the expression $p < .05$ means that the probability is less than 5 in 100 that the difference is due to chance alone; $p < .01$ means that the probability is less than 1 in 100; etc. Thus, the smaller the probability figure, the more significant a difference is and the less likely it is due to chance variation. In keeping with statistical convention, differences are not considered statistically significant here unless the probability is 5 in 100 or less.

The ANOVA test yields a statistic called the F ratio, which is the ratio of two variance estimates, and it is this F statistic that allows the probability determination. Similarly, the t-test and chi-squared test yield statistics that permit a probability determination of the significance of a difference. In all of these tests, reference is made to df, or degrees of freedom. The df refers basically to the number of independent measures on which the test is based.

The manner and degree to which two factors are related is expressed by the Pearson product-moment correlation coefficient (r). The value of r can be positive (+), indicating a tendency for the two variables to increase together or decrease together, or it can be negative (-), indicating that as one variable increases, the other tends to decrease, or vice versa. The numerical value of r can range from +1.00 to -1.00. An r value of 0.00 indicates no correlation between the two variables.

The reader desiring more information of such statistical analysis and test procedures is referred to any one of the large number of standard statistical textbooks available. For example, see:

Edwards, A. L. Statistical analysis. New York: Holt, Rinehart, & Winston, 1974.

McNemar, Q. Psychological statistics. New York: John Wiley & Sons, 1969.

Runyan, R. P., & Haber, A. Fundamentals of behavioral statistics. Reading, MA: Addison-Wesley, 1971.